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ABSTRACT

This curriculum guide was launched in response to a need for Lake Superior-specific educational materials and contains lessons and activities that can be used to teach about Lake Superior. The lessons in this book are divided into four sections. Each of the first three sections has a background section that provides basic information about Lake Superior. Following the background information each section provides a variety of activities and lessons designed for a variety of ages and settings. The first section, "The Physical Lake Superior," contains lessons that focus mostly on the physical evolution and dynamics of Lake Superior. The section titled "The Living Lake Superior" contains activities that teach about the plants and animals of the basin, from arctic disjuncts to zooplankton. "The Cultural Lake Superior" has lessons about the human dimension including history, human geography, and environmental issues. The last section, "Synthesis," is for those lessons and activities that are truly interdisciplinary and which go beyond the classroom walls. Appendices include resources, maps, and charts. (JRH)

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Lake Effects

The Lake Superior Curriculum Guide

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LAKE EFFECTS *The Lake Superior Curriculum Guide*

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Though many come and go who call me home,
Though I am used in ways beyond my dreams,
Here on my northern rim, I have not changed:
Moose still come down to drink and browse
Along my rugged shores,
The caribou still paws the rocks
To find my moss and lichen,
In sheltered bays and on my quiet streams
The beaver builds his lodge,
Stores birch and aspen against the winters cold.
At dusk, I hear the lonely call of whitethroats,
The haunting liquid trill of hermit thrush,
That music of the north,
The loon's wild quavering call —
Echoes from lake to hidden lake beyond my shores.
The osprey still soars high above my crags,
Screams and drifts in the boundless blue above me.
All this and more is still unchanged.

I am still the Lake Superior of old
Part of the wilderness that gave me birth.

—SIGURD OLSON, from *Lake Superior Speaks*

WELCOME!

Welcome to this first draft of LakeEffects: *The Lake Superior Curriculum Guide!*

LakeEffects was launched in response to a need for Lake Superior-specific educational materials. While acknowledging that there are many gaps in this first draft, we also recognize that the topic of Lake Superior, like the lake's surface, is very broad. This is a working copy: we are distributing what we have ready, but already looking ahead. Future issues of Lake Superior Center's program newsletter, *LakeEffects*, will be a source of new material to add to the guide. Each issue will provide a new lesson/activity for inclusion.

Many people have been involved in the production of this guide: classroom teachers, Lake Superior Center interns, Lake Superior Center staff, and countless others. It is the involvement of so many educators interested in improving Lake Superior education that makes this guide unique. It must also be noted that some of the activities in this guide have been adapted from other successful environmental education programs; we have tried to give credit to previous organizations and publications in these instances.

The listing on the previous page includes many of the people that contributed to the completion of this first draft. Our apologies in advance if anyone's name has been omitted. This has been, and will continue to be, a collaborative effort!

Underlying this project is the belief that if we capitalize on the natural attraction and fascination that people have for Lake Superior and promote a greater understanding of the systems and cycles that make up our great lake, then we will be on the way to ensuring that wise decisions will guard the lake well into the 21st century. Our mission is to be a part of the understanding, the stewardship, the fascination, the respect and the love of Lake Superior.

Further acknowledgment must be extended to the Blandin Foundation. The foundation's direct support of Lake Superior Center programs, the School Program Development Project Phases I and II, has provided the financial means to undertake this project. The School Program Development Project has included the following activities at Lake Superior Center:

- teacher involvement in Lake Superior curriculum development
- preservice teacher environmental education internships
- Lake Superior Center staff involvement in curriculum development
- *LakeEffects* curriculum production

The links forged between the Lake Superior Center and the Blandin Foundation further the collaborative identity of this guide.

HOW TO USE THIS ACTIVITY GUIDE

How do you teach about Lake Superior? Well, where possible, you step aside and let the lake do the teaching. But short of a three-day Lake Superior field trip (described in the "Synthesis" section), most educators will go for the interdisciplinary, hands-on approach. These lessons can help you do just that. There are four sections of lessons:

- The Physical Lake Superior
- The Living Lake Superior
- The Cultural Lake Superior
- Synthesis

Each of the first three sections have a background section providing basic information about Lake Superior. It is hoped that this information will provide support in terms of content information. Following the background, each section will provide a variety of activities and lessons. The material is designed for a variety of ages, settings, etc. The easy format should facilitate the use of the guide.

With the hope of contributing to interdisciplinary Lake Superior education, these sections are of course somewhat arbitrary. Still, they are a useful guide. In "The Physical Lake Superior," you'll find lessons that focus mostly on the physical evolution and dynamics of Lake Superior. In "The Living Lake Superior," you'll find activities that teach about the plants and animals of the basin, from arctic disjuncts to zooplankton. "The Cultural Lake Superior" holds lessons about the human dimension, including history, human geography and environmental issues. "Synthesis" is for those lessons and activities that just couldn't be categorized: truly interdisciplinary programs that go beyond the classroom walls.

Most of these activities can be done in or out of the classroom. The same round of "The Incredible Journey" done on a Lake Superior beach has a wholly different impact than when it's done in the classroom. Watch for instructions where called for as to location or setting of the activities in the Procedure section of the lesson plan.

Some units are described in the book; we encourage you to pull together your own sampling for a complete Lake Superior unit. You'll find there's a natural flow to Lake Superior lessons—the lake is an ideal subject for a month-long interdisciplinary unit.

We've tried to be fair and accurate in the range of grades given for which each activity is appropriate. That shouldn't stop you from stretching the capacity of your second graders, or adding some fun to the lives of your eleventh graders.

The lessons were developed from many sources. In environmental education, as in education as a whole, there is very little new under the sun. These activities bear the imprint of many other successful curricula. But they have all also been

through the grind here at Lake Superior Center, tested by their writers and their students in settings ranging from the classroom to the shores of the lake. The lawn in front of the Center has been a vital testing ground for some of our most fun activities.

The Freshwater Fellows were a core group of master teachers who designed many of the classroom-based activities found here. Preservice teacher-interns were also crucial to this process. And finally the contributions from the wonderful Lake Superior education community cannot be forgotten or too strongly thanked.

One last note: what you hold in your hand is only the first attempt at a Lake Superior Center curriculum. We intend to review it and update it numerous times, including a major editing and revision in late 1996 or early 1997. Please let us know what you think and how we could improve.

ABOUT LAKE SUPERIOR CENTER

Lake Superior Center is a private, non-profit organization based in Duluth, Minnesota. Our mission is to raise the general public awareness of Lake Superior and other large freshwater lakes of the world. Our primary means to achieve this mission is through education, specifically through the construction of a major freshwater aquarium which brings to life the dynamics and habitats of Lake Superior. The aquarium is scheduled to open in 1999.

GUARDIANS OF THE WATER

The importance of clean, fresh water in our lives is undeniable. Water is essential to life. The cells of living organisms contain at least 60 percent water; life cannot continue without a constant supply of water. We also use water to wash our bodies, our clothes, our dishes and our cars; we use it to water our lawns and our gardens. It has been estimated that in the United States, each person uses an average of 80 gallons (300 liters) of water every day!

When we look out over our great Lake Superior, it stretches endlessly to the horizon. It is easy to think that its resources are unlimited. In reality, Lake Superior contains 10 percent of the world's supply of fresh surface water. Fewer than 1 million people live within the Lake Superior watershed; this means that less than 1/50 of one percent of the world's population must act as the guardian for 10 percent of the world's surface freshwater resources. This is a very important role!

The more deliberately our attention is focused on our freshwater resources, the greater the chance that we will learn to respect the importance of water in our lives and work to keep our water supply clean. Because it's not really "our" water anyway, but the planet's and all its creatures'. The goal of this activity guide is to draw attention to a very important part of the world's freshwater supply—Lake Superior.

■ THE GREATEST OF LAKES

The Great Lakes make up the largest freshwater system in the world. The five Great Lakes cover a total area of 94,000 square miles, or 244,000 square kilometers, and contain approximately 18 percent of the world's supply of fresh surface water.

Lake Superior is the largest, deepest and coldest of the Great Lakes. Measured across its greatest dimensions, it is 350 miles or 563 kilometers long and 160 miles or 259 kilometers wide. It has a surface area of 31,700 square miles or 82,100 square kilometers—making it the largest freshwater lake in the world, based on surface area. It has a shoreline of 1826 miles or 3043 kilometers—if straightened out, it would reach from Thunder Bay, Ontario, to Vancouver, British Columbia. The deepest point of the lake, located about 40 miles or 65 kilometers north of Munising, Michigan, is 1335 feet or 405 meters deep. That is 732 feet or 223 meters below sea level! The lake holds approximately 3 quadrillion gallons, or 11.4 quadrillion liters of water—nearly half of the water in all the Great Lakes combined. The average annual surface water temperature for Lake Superior is approximately 40°F (4.4°C); the water is usually warmest in August, and even then, the average temperature is only 58°F (14.5°C).

The Lake Superior watershed, which lies within the political boundaries of Minnesota, Wisconsin, Michigan and Ontario, covers approximately 49,300 square miles, or 127,700 square kilometers. Within that watershed, more than three hundred short rivers drain into the lake. The St. Louis River, which forms part of

the boundary between Minnesota and Wisconsin and the Nipigon River in Ontario, are the largest tributaries of Lake Superior. Water flows out of Lake Superior through the St. Mary's River at Sault Ste. Marie, the southeast tip of the lake.

■ THE LAKE—A LINK TO THE NEXT GENERATION

Lake Superior is an immeasurably important resource for ecological, economic and social reasons. Two countries depend on this body of water for drinking water, irrigation, fish and wildlife habitat, transportation, recreation and electric power. Everyone living in the Lake Superior region, as well as anyone outside the region who uses and benefits from the lake's bounty, is responsible for its continual well-being. What is done to the lake in this generation affects not only those living here today, but also those living here in the future.

The lake also is dependent on humans to maintain sustainable levels of growth and responsible uses of its water, flora and fauna. The cost of inaction or insufficient action is vastly greater, in the long run, than the cost of timely action now. For the future, the Lake Superior region needs to seek growth through sustainable development *at no cost to the lake*—to strive toward a return to cleaner times and ensure the lake's availability for generations to come. One of the most effective and crucial ways of achieving this is through education. Citizens who value Lake Superior for all its riches and resources, who are "lake literate," are the link in a delicate chain which will ensure a healthy future for everything and everyone connected to Lake Superior.

...humans must make a choice as to the kind and scale of difference they make. If they choose to make too small a difference, they diminish their humanity. If they choose to make too great a difference, they diminish nature, and narrow their subsequent choices: ultimately, they diminish or destroy themselves.

—WENDELL BERRY, *Home Economics*

Contents

1. The Physical Lake Superior

INTRODUCTION TO THE PHYSICAL LAKE 2
LESSON PLANS
- All the Water in the World 10
- A Great Lake Superior 13
- The Incredible Journey 16
- Making Waves 19
- A Bucket Full of Stories 21
- In One Lake and Out the Other 23
- More Than Just a Lake! 26
- Weathering Lake Superior 30
- Superior Lakewatch 35

EXAMINING THE GREAT LAKES Unit 39
- Whaddya know? 40
- Depth Soundings 45
- Taking it Personally 48
- Big Lake, Big Basin? 50

2. The Living Lake Superior

INTRODUCTION TO THE LIVING LAKE 54
LESSON PLANS
- Lake Superior Circle of Life 63
- Owl and Mouse 65
- Getting Acquainted With Aliens 67
- Mussel Mania 71
- Getting to Know the Watershed 74
- Sturgeon Stories 85
- You "Otter" Be There 88
- Reforesting Superior 90

3. The Cultural Lake Superior

INTRODUCTION TO THE CULTURAL LAKE 94
LESSON PLANS
- Food Chain Tag 103
- Ruffe Public Hearing 106
- Would You Drink This Water? 112
- A Lake Superior Raindrop Journey 115
- A Lake Like No Other 118
- Lake Superior Poem 121
- Lake Superior Geography Concentration 123
- Great Lake Settlement: Anishinabe 126
- Voyageur—Introducing Me! 137
- Unreserved Judgment 145

4. Synthesis

LAKE SUPERIOR QUIZ SHOW 162
LAKE SUPERIOR FIELD TRIP "HOW TO" GUIDE . 167
LAKE SUPERIOR A-Z Unit 175
- A-Z Introduction 176

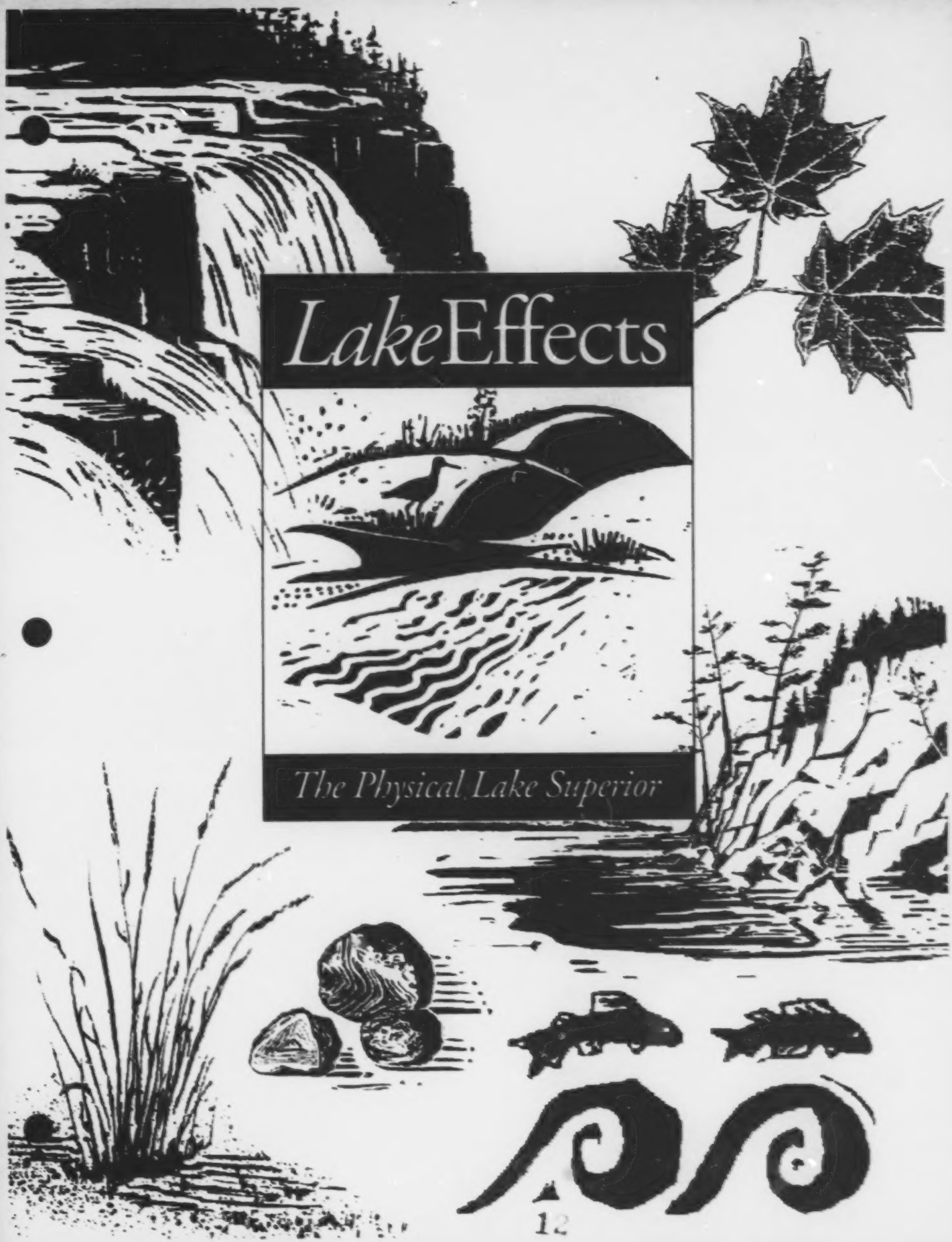
CLEANER STREETS, CLEANER WATERS 186
WHAT IS A LAKE? Unit 188
- Intro to Lake Terminology & Processes 190
- Create an Artificial Lake 193
- Group Research 194
- Use of Sampling Equipment 198
- Lake Sampling 199
- Analyzing the Data, Writing the Report, Presenting Results 200

Contents, cont'd.

Appendix

MAKING YOUR OWN LAKE SUPERIOR FLOOR MAP 204
GLOSSARY 205
RESOURCES 210
PHOTO-READY MAPS, CHARTS, etc.
- Lake Superior Outline 212
- Lake Superior and Drainage Basin 213
- Bottom Topography of Lake Superior 214
- Great Lakes Data Chart 215

LAKE SUPERIOR FISH CONSUMPTION ADVISORY 216
FEEDBACK/"LAKEEFFECTS" SUBSCRIPTION FORM 217



Lake Effects

The Physical Lake Superior

THE GEOLOGY

Although Lake Superior itself is relatively young in terms of geologic time, the Lake Superior basin has a long, complex geologic history that involves continental rifting, volcanic activity, erosion and glacial ice. Rocks surrounding the basin include some of the oldest known rocks on the North American continent as well as much younger rocks that contain fossils from shallow seas that once covered much of North America.

THE CANADIAN SHIELD: FOUNDATION OF NORTH AMERICA

The history recorded in the rocks of the Lake Superior region began several billion years ago. Rocks along most of the Canadian shoreline of Lake Superior are part of the Canadian Shield. The oldest of these rocks have been dated at 3.3 billion years old. This ancient shield represents the remnants of the earliest continental rocks; it is composed primarily of igneous and sedimentary rocks that were buried, then highly metamorphosed and deformed before being once again exposed on the earth's surface. These rocks contain deposits of gold, silver, and sulfides of copper, zinc, and nickel that have been mined for many years in Ontario.

Around 2 billion years ago, when the rocks of the Canadian Shield were already nearly a billion years old, evidence indicates that there may have been a shallow marine basin in approximately the same location as the present-day Lake Superior basin. Fine muds were deposited in deeper portions of the basin, and alternating layers of chert and grains of iron, now known as iron formation, were deposited along the shoreline. This period of iron deposition was unique in the earth's history; it has not occurred since that time, but it left behind the famous iron ranges of Minnesota, northern Wisconsin, and the Upper Peninsula of Michigan. The iron range towns of northern Minnesota, from Grand Rapids on the west to Babbitt on the east, grew up adjacent to, or in some cases, on top of, the iron deposits. Draw a line from town to town and you will see the shoreline of the ancient basin.

THE GREAT RIFT VALLEY OF LAKE SUPERIOR

Rocks exposed along the southwestern Lake Superior shoreline are 1.1 billion year old volcanic and intrusive igneous rocks that resulted from *rifting*, a process in which the continental crust was pulled apart by extensional forces, resulting in thinning and fracturing of the rocks. The rifting tore apart the rocks of the earliest continent, allowing molten lava to flow out over the earth's surface. The volcanic rocks resulting from the lava flows are well-exposed along Minnesota's North Shore. Palisade Head and Shovel Point at Tettegouche State Park are part of a very thick and resistant flow. At Gooseberry Falls State Park, the waterfalls on the Gooseberry River flow over "stairsteps" formed by a series of separate lava flows. The volcanic rocks also form the beautiful Porcupine Mountains in Michigan's Upper Peninsula.

Molten material that did not make it all the way to the ground surface

cooled slowly in cracks and fissures beneath the lava flows, forming the coarser-grained intrusive rocks that are now exposed on the high ridges known as the Sawtooth Mountains that parallel Minnesota's North Shore.

Erosion of the volcanic rocks occurred between eruptions. The sedimentary rocks of northern Wisconsin's shoreline and the Keweenaw Peninsula of Michigan are interlayered with volcanic rocks and are composed of volcanic sediments eroded during periods of little or no volcanic activity. After the volcanism ceased, the continent slowly sagged along the axis of the rift, leaving a basin that eventually filled with sediment.

At some later time, hot fluids moving through the rocks left behind some interesting minerals; very fine-grained silica deposited in gas bubble holes in the volcanic rocks created agates. Native copper deposited in both the volcanic and sedimentary rocks of the Keweenaw Peninsula formed deposits rich enough to be mined.

■ SHALLOW SEAS

Millions of years after the volcanic activity ended, shallow sea water advanced from the south, covering much of the North American continent and reaching at least as far as what is now the Upper Peninsula of Michigan. Sand and silt were deposited along the shoreline of the sea, and coral reefs formed in deeper water. These sediments became the sandstones and limestones now exposed along the Lake Superior shoreline of the Upper Peninsula.

The sandstones are exposed in the cliffs at the Pictured Rocks National Lakeshore. Minerals carried by groundwater have been deposited on the face of the cliffs, giving them their colors, or "pictures." Sedimentary features, such as ripple marks and cross-bedding, are preserved in the rocks and can be seen in several areas along the shoreline, attesting to the role of water in the transport and deposition of the particles that make up the rocks.

■ GLACIAL TIMES

Few rocks remain to tell us of the conditions between 400 million and 1 million years ago. Sediments present on the ground surface tell us that glaciers covered the Lake Superior area for thousands of years, beginning about 1 million years ago; the glaciers advanced, covering the land with ice, then receded, leaving tons of sediment behind as the ice melted.

At least four periods of this episodic advance and retreat of glacial ice are recorded in the sediments left behind. In parts of northwestern Minnesota, the glacial sediments, known as *till*, are nearly 500 feet (150 meters) thick. In other areas closer to Lake Superior, the till is thin or nonexistent.

The most recent glacial advance began about 75,000 years ago and ended around 10,000 years ago. Most of the surface topography of the Lake Superior region is a result of the glaciers. The glaciers removed sediment from some areas and deposited it other areas, leaving behind piles of till with exotic names like moraines, drumlins, eskers and kames.

The ice scoured out and carried away the soft sediments that had filled the Lake Superior basin, and as the last ice melted, meltwater filled the basin. At its highest level about 12,000 years ago, known as Glacial Lake Duluth, the water surface stood at 1099 feet (335 meters)—approximately the elevation of Duluth's present-day Skyline Drive. During this time, many feet of iron-rich clays were deposited in the lake basin; the abundance of iron in the sediment gave it a soft, red color.

■ AFTER THE GLACIERS

As the glacial ice disappeared, the water level in the lake dropped. Water flowing down the St. Louis River into Lake Superior eroded through this soft red clay, carving out a channel and exposing the high clay banks in the Duluth/Superior area. When the water level in the lake rose again, the channel of the river was partially "drowned," forming the estuary and backwaters we see today.

One of the youngest geologic features in the Lake Superior basin is Minnesota/ Wisconsin Point, the natural sandbar that separates the Duluth/Superior harbor from the lake. This is an excellent example of a ***baymouth bar***, which is a long, narrow bank of sand or gravel that is deposited by wave action across the mouth of a bay. The bar connects headlands on either side of the bay, acting to straighten out the shoreline. The formation, 10 miles in length, forms the longest freshwater sandbar in the world. Minnesota/Wisconsin Point is probably only about 5,000 years old; it is composed of sand, some of which was transported by the St. Louis River from inland areas, and some of which was transported by waves along the shoreline of the lake. The strong wind blowing off the lake has piled the sand into dunes, which change shape as the wind direction shifts. Dunes migrate slowly as sand grains are carried up the face of the dune by the wind and deposited on the downwind side as the wind velocity decreases.

THE HYDROLOGIC CYCLE

We forget that the water cycle and life cycle are one.
—Jacques Cousteau

■ HOW DOES IT GET THERE?

Water enters the Lake Superior basin from direct precipitation, surface runoff, and groundwater. Each year, an average of approximately 2.5 feet (0.8 meter) of water falls on the lake as rain or snow. An additional average of 2 feet (0.6 meter) enters the lake through surface runoff from streams and rivers. Runoff is highest in the spring during the snowmelt. The contribution from groundwater appears to be minimal.

■ HOW LONG DOES IT STAY: RETENTION TIME

Of this 4.5 feet (1.4 meters) of water that enters the lake each year, it is estimated that 1.6 feet (0.5 meter) is lost to evaporation. The remainder eventually flows out of Lake Superior into the lower Great Lakes. *Retention time* is a measure of the length of time that a drop of water remains in the lake. It is calculated using the volume of water in the lake and the average annual rate of outflow. Since the completion of a gated dam at the head of the St. Mary's River in 1921, the outflow from Lake Superior has been controlled at an average annual of 77,683 cubic feet/second (2,200 cubic meters/second). The retention time for Lake Superior has been calculated to be approximately 191 years. So, once a drop of water enters Lake Superior, it may take 191 years for it to leave the lake by way of the St. Mary's River. If that drop of water carries pollutants with it, the pollutants will also remain in the lake for 191 years. In contrast, the retention time for Lake Erie has been calculated to be just 2.6 years. Since all of the five Great Lakes are interconnected, the water quality of downstream lakes is highly dependent on the quality of the upstream lake water.

WATER PROCESSES

Lake Superior is the northernmost of the Great Lakes. It is also the deepest and contains the largest volume of water. Such a large volume of water requires an equally large amount of solar energy to heat it. But because the lake is located so far north, it does not receive as much solar energy as the other Great Lakes. For these reasons, Lake Superior's maximum surface water temperature is the lowest and the daily rate of temperature increase or decrease is the smallest of all the Great Lakes. The average annual surface water temperature for Lake Superior is approximately 40°F (4.4°C).

■ THERMODYNAMICS

Lake Superior is not simply a large body of uniformly-mixed water. Water is unique; unlike other substances, which are most dense as solids, water is most dense at a temperature of 39.2°F (4°C), while still liquid. As the temperature of the water drops below 39.2°F (4°C), the density decreases. When the water freezes and becomes a solid, the ice is less dense than the water—this is why ice floats in a glass of water, or on the surface of a lake. This unique property results in *thermal stratification* in lakes, where water forms distinct layers of different temperature.

■ A YEAR IN THE LAKE

In summer, surface and nearshore water is warmed by the sun, making it less dense than the colder water below. This warmer water forms a layer called the *epilimnion* at the surface of the lake. The sun's heat energy does not reach the deeper water, so it remains colder and denser, forming a layer called the *hypolimnion*. The *thermocline* is a narrow transition zone between the epilimnion and the hypolimnion marked by temperature that decreases rapidly with depth. In Lake Superior, this summer stratification usually is

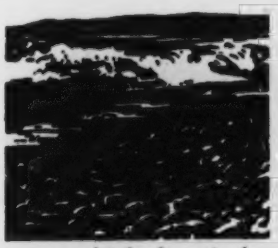
not fully established until the end of June or early July.

In the fall, surface water temperature begins to decrease as the sun's energy weakens. As the surface water cools, it becomes denser, and it begins to sink and mix with the colder water below. As the cooling intensifies, the mixing penetrates to greater depths, breaking down the thermal stratification of the summer. Mixing eventually destroys the thermocline, producing a water mass with nearly equal temperature. This process is known as *overturn*. In Lake Superior, this overturn period lasts far longer than most other lakes—sometimes as long as two months.

In winter, as the air temperature drops lower and lower, the surface water cools even further until ice begins to form. During the winter, the water of the lake shows only weak thermal stratification. Water in the deepest regions remains around 2-4°C, while surface and shallow near-shore water reaches 0°C and freezes. Fast ice, secured to the shoreline, is usually found primarily in shallow, sheltered areas. Ice that forms in more open areas is usually transitory, being frequently broken up by wind and wave action. Lake Superior can freeze over completely during intervals of very cold, calm weather, as occurred in the winter of 1993-1994.

In spring, the water temperature does not increase significantly until after the ice melts. Once the ice is gone, warming of the water begins in the shallow near-shore zone and progresses to deeper regions. When the surface water warms to 4°C, it becomes more dense than the colder water beneath it. The warmer water sinks and mixes with the colder water below, until the entire water mass reaches 4°C. Like in the fall, this overturn period lasts far longer on Lake Superior than on smaller lakes: up to two months. As the surface water warms, the summer stratification cycle begins once more.

Because of this extensive turnover, the water in Lake Superior is very well mixed. While the retention time is around 190 years, the lake water is completely mixed every three years.



WATER, WIND AND WAVES

Fetch is a term used by scientists and sailors for the area of open water over which the wind can blow in a given direction, thereby creating a wave system. Lake Superior is 350 miles (563 kilometers) long, measured southwest to northeast, and 160 miles (257 kilometers) wide, measured northwest to southeast. Lake Superior's most violent storms occur when the wind blows from the direction of greatest fetch. In the Duluth/Superior area, this is when the wind blows from the northeast; at the eastern end of the lake, this is when the wind blows from the northwest. Winds in excess of 67 mph have been recorded by ships during intense storms.

These strong, unidirectional winds cause *storm surges*, which are similar to what happens when you tilt a pan full of water. The water is temporarily displaced to one end of the lake; when

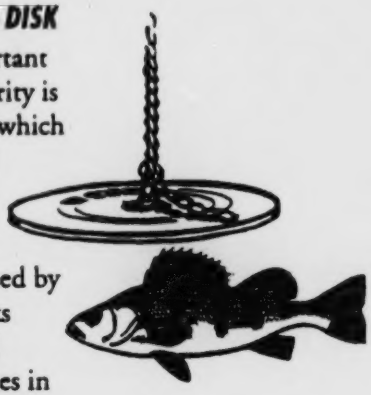
the wind subsides or changes direction, the water sloshes back and forth from one shore to the other in cycles of decreasing amplitude. This cycle of sloshing is called a *seiche* (pronounced "saysh").

Considering that Lake Superior holds approximately 3 quadrillion gallons (11.4 quadrillion liters) of water, it is understandable that wave action causes erosion of the shoreline and stirs up bottom sediments, resulting in increased turbidity. The largest wave recorded on the lake between 1960 and 1972 was almost 30 feet (9 meters) high—as tall as a three-story building!

Even on a calm day, with no storms causing surges, Lake Superior's waves usually approach the shore and strike land at some angle other than 90°. This causes the water to move laterally along the shore, a phenomenon known as a *longshore current.* As sediment on or near the shore is carried by the waves, it is transported in the same general direction as the longshore current; this movement of sediment parallel to the shoreline is called *longshore drift.*

Because the longshore currents tend to move in a fairly consistent direction, which for Lake Superior is counterclockwise, there is continual transport of sediments from one end of a beach to the other. This movement of sediment is a natural beach process; if no new sediment is brought in by waves or rivers, the beach will erode at one end and build at the other end, gradually moving in the direction of the current.

WATER CLARITY AND THE SECCHI DISK



The clarity of our waters is important to us. In Lake Superior, water clarity is affected primarily by two factors which may cause the water to be turbid —having or containing suspended sediment and algae.

Suspended sediment may be caused by natural erosion from stream banks and lake shores, or by accelerated erosion linked to land use activities in the watershed. Such activities may include farming, logging and construction. A lake that is turbid due to suspended sediment looks cloudy or muddy.

The second cause of turbidity is algae. These microscopic plants, also known as phytoplankton, occur naturally in all lakes. The kinds and quantities of algae are related to a lake's nutrient levels, and vary from season to season and lake to lake.

One of the simplest, yet most effective monitoring tools routinely used by aquatic scientists to measure water clarity is the Secchi disk. It is an eight-inch diameter disk attached to a non-stretchable rope. To take a Secchi reading, the observer lowers the Secchi disk into the water and measures the point at which it disappears, then pulls it up slowly until it reappears. The average of these two measurements is the Secchi reading. The deeper the Secchi reading the less turbid or clearer the water is.

By knowing a lake's Secchi depth, or Secchi disk transparency, we can roughly estimate its general productivity, or determine if the lake is suffering

from turbidity caused by runoff. To do this, however, we need data collected over a long period of time, particularly in the summer months when algal blooms are most prevalent.

Because factors other than suspended sediment and algae can affect Secchi transparency, we carefully control when and how a measurement is taken. Secchi disk measurements should be taken on the shady side of the boat only on relatively clear, calm days between 10 a.m. and 4 p.m. to prevent sun, rain, and clouds from interfering with readings.

Visitors to Lake Superior are usually struck by the clarity of the water. In 1665, Father Claude Allouez reported that he saw clearly to a depth of six brasses, which is equivalent to 32 feet (9.8 meters). During a mid-nineteenth century canoe journey on the lake, Charles Laman wrote, "I have frequently lowered a white rag to the depth of 100 feet and been able to discern its every fold or stain." More recently, tests conducted with Secchi disks have established the clarity of the water in certain areas to be between 65-75 feet (20-23 meters)!

WEATHER PATTERNS

Because of its immensity, Lake Superior acts as a reservoir of heat energy that affects the climate of the surrounding region. This is known as the *lake effect.*

In the summer, the water acts as a huge *heat sink*, absorbing and storing the sun's heat during the day. At night, as the surrounding air cools, the lake becomes a *heat source,* releasing heat back into the atmosphere. But the water in the lake is so deep and the volume so great, that it takes most of the summer to warm the water; the lake water does not reach its highest temperatures until late August.

The average temperature of Lake Superior in August is 58°F (14.5°C). In comparison, Lake Erie's average temperature in August is 73°F (22.9°C)! This large mass of cool water acts as a natural air conditioner. A breeze off the lake will bring delightfully cool air to the shore, even on a hot summer day.

For the same reasons, once the water is warmed in late summer, it takes a long time to cool again. In winter, with less heat provided by the sun, the surrounding air is cooler than the lake water. The lake gives up its stored summer heat slowly, forming billowing clouds of steam above the water in December and January. Because the lake has so much stored heat, it usually does not freeze until February. The slow release of this heat energy through most of the winter helps to moderate the temperatures of the surrounding land, keeping near shore areas warmer than inland areas.

Lake effect snow, which is a concentrated band of heavy snow downwind of the lake, occurs as the wind blows across the lake, picking up additional moisture, which is squeezed out and falls as snow when the air mass reaches the colder land. Major snowbelts (areas that receive an average of 98-138 inches (250-350 centimeters) of snow each year) occur on the south and east shorelines of Lake Superior, the areas

downwind of the prevailing winter winds.

In the spring, as the strength of the solar radiation increases, warming the air, the lake may stay frozen long after spring flowers start to bloom. Most of the heat energy from the sun goes into melting ice rather than warming the water below. Actual warming of the water does not occur until after all the ice is melted. The average temperature of Lake Superior in April is just 34°F (1.3°C), and the average May temperature is 37°F (2.6°C). In contrast, by May, Lake Erie has usually warmed to nearly 50°F (9.8°C).

TOPIC
Lake Superior as part of the world's water cycle.

AUDIENCE
Grades 3-8; 5-60 students

LENGTH
10-30 minutes

GOAL
To understand how Lake Superior's freshwater volume fits into the "bigger picture" of the world's total water volume.

OBJECTIVES
- *Students will be able to describe the different forms of water found on earth and give rough percentages of the quantities of each form.*
- *Students will be able to describe at least one action they can take to preserve Lake Superior's freshwater.*

MATERIALS
FOR LARGE-GROUP DEMONSTRATION—
- *clear container capable of holding at least four liters of water, preferably 12-20 liters*
- *smaller metric measuring units: one-liter cup*
- *set of metric measuring spoons or vials*

FOR SMALL-GROUP PROJECT— EACH WORK GROUP OF 3-4 STUDENTS WILL NEED THE FOLLOWING
- *4-liter bucket (ice cream pail is fine)*
- *set of graduated cylinders, including 100 ml measure and 50 ml measure*
- *set of metric measuring spoons.*

FOR LARGE GROUP ACTIVITY
- *index cards, one per student (see Getting Ready)*

All the Water in the World

How does Lake Superior's freshwater volume fit into the world's total water volume? Explore this important question through a demonstration of global water quantities, a group activity, or a small-group challenge.

BACKGROUND

Lake Superior contains one-tenth of the world's surface freshwater. How does Lake Superior's water fit into the "big picture" of water world-wide? It turns out that surface freshwater is very rare—only 0.018% of the world's total.

GETTING READY

FOR DEMONSTRATION METHOD—

Calculate the number of tablespoons in your large container (#of gallons times 256). This number will be the variable "X" in the GLOBAL WATER TABLE. Identify proper quantities for your container of water based on the following percentages (remember 3 teaspoons = 1 tablespoon; 4 tablespoons = 1/4 cup).

Or in the case of metric measuring tools, remember that 1 liter has 1000 milliliters, or 100 centiliters. (In this case, "X" is the number of milliliters in your large container.)

Fill your large container with tap water.

FOR LARGE-GROUP ACTIVITY—

Prepare cards. They should be marked on one side either "Fresh" (3%) or "Salt" (97%) in proportion to the amount of salt and freshwater in the world. On the the other side, in different color ink, mark the cards either "Ice," (75%) "Groundwater," (22%) or "Surface" (3%) in proportion to the different types of fresh water in the world.

Global Water Table

Form of Water	% of world's total		ml or Tblsp
1. Oceans and salt lakes	97.236	times X=	_____
2. Icecaps and glaciers	2.14	times X=	_____
3. Groundwater	0.615	times X=	_____
4. Surface freshwater: rivers and freshwater lakes	0.018	times X=	_____

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For a class of 25, have on the first side 24 labelled "Salt" and 1 labelled "Fresh."

On the other side, have 19 labelled "Ice," 5 labelled "Groundwater" and 1 labelled "Surface" (use the back of the one labelled "Fresh" for the "Surface" card).

PROCEDURE

1. Introduce activity

Explain that the students are going to learn about a precious resource—water! Brainstorm ideas of where water is found. If appropriate, write the responses on the board. Possible answers include:

Lakes
Rivers
Oceans
Icecaps
Groundwater
Sink/bathtub/faucet
Clouds
Human body (60-70% of the human body is water)

2. How do we use water?

Ask students how they use water. For groups who live near Lake Superior, ask how they use Lake Superior water. Explain that for this activity, we'll be looking for water we can swim in, fish in, and drink from.

3. Different methods. Choose the best for your group!

3A. LARGE-GROUP DEMONSTRATION

- Show students the large container full of water. Explain that you're going to pretend that this is all the water in the world. Explain that if this is all the water in the world, almost all of it is in one place. Ask for guesses as to where that is. The oceans have 97% of all the water in the world. Can you drink the water in the ocean? No. That leaves 3% that's "fresh."
- With the liter, half-liter or gallon/Tblsp measurements, pull out 3% of the water (total of #s 2-4 on the Global Water Table). Explain that this is all the freshwater in the world.
- Explain that most of the freshwater in the world is found in places other than in rivers and lakes. Ask for ideas of where else freshwater would be found. Explain that most of the freshwater is either locked up in glaciers (like in Antarctica) or in groundwater. Using the measuring spoons, pull out of the half-liter measure the water representing icecaps and glaciers (#2 above) and groundwater (#3 above). You can't drink the icecaps, and you can't fish in groundwater.
- Explain that the remaining bit (should be the amount in #4 above) is all the freshwater contained in the lakes and rivers in the entire world. It is the water we can fish in, swim in and drink!

3B. SMALL GROUP PROJECT

- Write the comparative percentages of world water on the board. Divide students into work groups of 3-4 students each. Give each work group a four-liter container full of water, and a set of graduated cylinders, including a 100 ml measure and a 50 ml measure, plus a set of metric measuring spoons.
- Have each group figure out the proportions of the five categories of water assuming that the four liters are all the water in the world. Have

them fill the cylinders and measuring spoons with water to represent ice, groundwater and surface freshwater.

3C. LARGE GROUP ACTIVITY

- Have students standing in a large, open area. Explain to the students that they represent all the water in the world. Hand out the cards with either "Salt" or "Fresh" facing up. Ask students to read their card and then keep it hidden.
- Ask the group what are the two general kinds of water in the world, from what they see on their cards. Ask students how they might act out "saltwater" and "freshwater" (generally big waves is the response for saltwater, and either little waves or drinking from a glass is the response for freshwater).
- Have the students act out whatever motion is assigned to their card, then try to join up with the other students acting the same way, so that "all" the saltwater and "all" the freshwater are in their separate groups. It will be apparent pretty quickly that all but one or two of the students are in the saltwater group. Go to each group and ask "Can you drink it? Can you swim in it? Can you fish in it?" Explain to students that this is really the way it is; only a little bit of the world's water is fresh. (Students can simply stand for salt or fresh if space is limited.)
- Explain to students that they will now do the same thing, except they will now be all the freshwater in the world. Have students flip their cards over, read the card then keep it hidden. Decide on motions for ice (shivering), groundwater (crawling on ground), and surface water (splashing). Have students act out motions and work into groups. Again, the surface water group is very small (one or two kids). Go to each group and ask again "Can you drink it? Can you swim in it? Can you fish in it?"

4. Wrap-up (All three methods)

Discuss with the group the implication of having so little surface freshwater in the world. This is the water that we can drink, fish in, and swim in. Explain to students that of all the surface freshwater, 10% is in Lake Superior, and 20% in the Great Lakes all together. What responsibility do we have to the rest of the world in terms of how we treat Lake Superior?

ASSESSMENT

Watch for students referring to the relative amounts of water in the world in future Lake Superior lessons.

EXTENSIONS

Try "The Incredible Journey" as an additional class lesson.

A Great Lake Superior

How much total water is held in Lake Superior? Use this leson as demonstrations or a classroom lesson to create visual representations of Lake Superior, Lake Baikal, and the relationship between the effects of pollution and surface area and retention time.

TOPIC
Lake Superior's size and volume in relationship to pollution susceptibility.

AUDIENCE
Grades 3-8; 5-30 students

LENGTH
30-40 minutes

GOAL
To understand that the enormous volume of water in Lake Superior, one-tenth of the world's surface fresh water, is a small fraction of Earth's total water.

OBJECTIVES
- *Students will be able to identify available fresh water as a small fraction of the world's water supply.*
- *Students will be able to describe the depth of Lake Superior as very small when compared to the size of the surface area.*
- *Students will understand how the enormous surface area of Lake Superior makes it susceptible to airborne pollutants.*
- *Students will understand that the amount of time for enough "new" water to replace all the Lake's current water is called retention time. Retention time for Lake Superior is almost 200 years!*

MATERIALS
- *2 clear pitchers*
- *overhead made from Lake Superior map (in Appendix)*
- *1 broad and shallow clear plastic tub*
- *1 deep and narrow clear plastic tub*
- *1/2 c flour*
- *1 sifter*
- *1 empty aquarium or other large clear container*
- *2 x 500 milliliter beakers or mayo jars*
- *red food coloring*

BACKGROUND

See "All the Water in the World" lesson plan for additional detailed background information.

The amount of time for enough "new" water to replace all the lake's water is called retention time. It is also called renewal time, or flush rate. It is a useful concept because it gives you an idea of how often the lake water is "renewed." The amount of time varies greatly—from 2.6 years for Lake Erie, to 191 years for Lake Superior.

Many toxic substances enter Lake Superior via the atmosphere, carried with precipitation or dust. Toxics such as PCBs, dieldrin, toxaphene, mercury, and DDT are threatening due to their ability to remain in the waters and sediment for a long period of time, as well as for their ability to bioaccumulate in animal species such as fish.

PROCEDURE

PART A: HOW MUCH WATER IS IN LAKE SUPERIOR?

(see also ALL THE WATER IN THE WORLD)

1. The salt(water) of the earth

Fill a pitcher of water, and leave one empty. The full one represents all the water in the world! One student can pour water from the full pitcher to the empty one. Ask the pourer to pour that amount of the world's water that is salty (oceans) into the empty pitcher. Ask the group to tell the pourer when to stop—i.e. when they think that the amount of world ocean water has been poured. Compare the amount that the group of students believe is salty, with the actual 97% (i.e. almost all of the pitcher water!).

2. Chosen frozen

Consolidate the water and ask the group to think of it as all of the FRESH water in the world. Ask a new pourer to pour all of the frozen freshwater out of the full pitcher. Again, ask for audience encouragement. The correct answer is about 97%. Ask the students where all of this ice is—the poles, glaciers, etc..

3. Groundwater

Consolidate the water again. This time the water will represent all of the FRESH LIQUID water in the world. Ask a new pourer to pour out all of the underground water out of the pitcher. Sources vary, but you will need to pour out 75-90% of the pitcher water!

The tiny amount that is left: LIQUID, SURFACE, FRESH WATER is one of the most important commodities in the world—and Lake Superior is but one tenth of the remaining water!

PART B: HOW BIG IS LAKE SUPERIOR?

1. Surface Area

Show the overhead that illustrates Lake Superior surface area. Explain that it is 350 miles in length, approximately the size of Scotland. If we could drive down the length of the lake in a car at 50 mph, how long would it take? (7 hours)

2. Depth

Ask the students to imagine shrinking Lake Superior down to a scale that would fit into the classroom. If Lake Superior was only 20' long, how deep would it be? Ask the students to estimate using their hands held horizontally. The answer is approximately one centimeter. Lake Superior is remarkably shallow given its surface area. It is like a thin film of water on the earth's crust, averaging about 450' deep (about 1/2 the size of an ore boat).

3. Surface area and pollution

Invite two students to hold the two tubs-one narrow and deep and one shallow and broad. The narrow tub represents Lake Baikal in Russia, which has more than twice the amount of water as Lake Superior has. The shallow one represents Lake Superior. The flour is to represent airborne pollution. Before the students sift flour on both pans at an equal rate, ask them to make a hypothesis about which "lake" will receive more "pollution." The students should see that there is more flour (total) on Lake Superior because of its broad surface area. Ask the students why surface area is important in regards to airborne pollutants...big surface areas can make large lakes like Superior susceptible to airborne pollutants.

PART C: RETENTION TIME— IS DILUTION A POLLUTION SOLUTION?

1. Pollutants

Fill one of the beakers or jars with tap water and stir in a few drops of food color so that it is bright red. Explain to the students that the red food color is to represent a pollutant that is in a nearby lake. It is nice to think that rainwater could eventually dilute the pollutant so that the lake would be clean again. Ask students how long they think this might take.

2. Clean water renewal

Try one complete renewal of water. To do this, fill the second beaker with tap water; this will represent the amount of rain and other new water that would completely replace the existing lake water. Have a student hold the "polluted" beaker over the aquarium (or a bucket) while the clean water is gradually poured into the "polluted" beaker. The waters will mix and overflow into the aquarium/bucket, and it will be evident that much of the "pollutant" is gone from the lake. Ask the students if all of the "pollution" is gone from the lake? If you can still see the red, you have demonstrated that more than one retention time is needed to flush pollutants from the imaginary lake. It will typically take 3-4 replacements before you can no longer see the "pollutant". After the additional water replacements ask the students if they feel sure that the "pollutant" is completely gone from the "lake." Actually our eyes are rather unreliable at detect-

ing pollution—small amounts of pollutants tend to be invisible to us.

3. Retention time

Introduce the concept of retention time, and that it varies from lake to lake, with small lakes "flushing" more quickly than large lakes. Typical retention times for medium-sized lakes in the Midwest is on the order of 3-10 years. Large lakes, like Superior take much more longer. Calculate the number of generations that it would take for Lake Superior to renew twice (200 x 2 divided by 25 =16 generations). That is why we must protect our lakes now, and prevent pollution that will be with us for so long.

4. "Away"

Be sure to go back and examine the water that overflowed from the "polluted" lake. Did the pollutant go away? Discuss what "away" means. It is a key problem in pollution control that we often move pollutants around, rather than solve the problem. Another aspect of the dilution "solution" is to consider the source of the renewal water, if this water is polluted, the lake may never be clean again!

ASSESSMENT

For both student retention and assessment reasons, ask students to write a paragraph addressing the following topics: Lake Superior surface area, depth, retention time, susceptibility to pollutants, etc.

The Incredible Journey

Take students on an incredible journey by transforming them into water molecules of the Lake Superior water cycle. As they roll the dice to move among eight kinds of water, they'll learn about retention time and other unique features of dynamic Superior.

TOPIC
The Lake Superior water cycle.

AUDIENCE
Grades 1-12

LENGTH
20-30 minutes

GOAL
To understand how Lake Superior fits into the world's water cycle.

OBJECTIVES
- *Students will be able to list and describe the parts of the Lake Superior water cycle and how the parts relate.*
- *Students will be able to describe the retention time of Lake Superior and at least one action they can take to preserve Lake Superior.*

MATERIALS
- *large floor map of Lake Superior or a taped/chalked floor outline of the lake (optional)*
- *8 boxes, each about 6 inches on a side. (These are the "dice" for the Incredible Journey, and will be labelled as shown in the Water Cycle Table. Regular dice can be used and a table created to correspond with the numbers, e.g. "1-3=Stay in Lake...")*
- *writing equipment: pens, notebook, clipboard (optional)*

BACKGROUND

Lake Superior contains one-tenth of the world's surface freshwater. This lesson explains the different parts of the Lake Superior water cycle and how those parts fit together. It's impossible to separate Lake Superior from its tributaries, outlets and the other ways in which water flows in and out.

PROCEDURE

1. Getting oriented (optional)

Unroll large map or create tape/chalk outline of Lake Superior on floor. Get students to orient themselves to some familiar landmarks, e.g. Duluth, Sault Ste. Marie, the different states and provinces, Isle Royale, etc. Where does water enter Lake Superior from? Where does it leave?

2. Where's the water?

Ask students where water might be found in nature around Lake Superior. As they give correct answers, lay out the signs with the answers on them near the floor map. These are the stations: *Soil, Plants, Rivers, Clouds, Ocean, Lake Superior* (placed on floor map), *Fish* (should be placed in or adjacent to Lake Superior), *Groundwater.* Explain to students that they are going to become water molecules as they move through the Lake Superior water cycle.

3. Getting ready to roll

Divide students evenly into each station; each station should also have its appropriate die. Have students identify the different locations water can go from their station in the water cycle by reading the sides of the die for that station. Discuss the conditions that cause the water to move (from the water cycle table).

4. Roll 'em!

In this game, a roll of a die determines where water will go. Students line up behind the die at their station. Students roll the die and go to the location indicated by the label facing up. If they roll "stay," they move to the back of the line. When students arrive at the next station they get in line and start over again.

5. Wrap-up

With students sitting down in a group, briefly discuss some of the "stories" that emerge. Ask where water goes and where it stays. Where were the longest lines? The shortest? A couple of patterns may emerge:

- "Water" goes into the "clouds" fairly often, but moves out quickly again.
- "Water" also goes into "Lake Superior" often, but tends to stay there.

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In fact, the typical water molecule stays in Lake Superior for almost 200 years. Imagine a Lake Superior die with 191 sides; 190 sides read "stay," and you can only roll the die once a year!

Explain the game in terms of the water "cycle," how all the water in the world keeps flowing around. Given that Lake Superior holds 10% of all the freshwater in all the lakes and rivers in all the world, what can we do to take care of it? Brainstorm a list:

- Reduce consumption of fossil fuels, to keep down the air pollution that might end up as toxic or acid rain falling on the lake.
- Be careful with potentially hazardous household products such as drain cleaner, paint thinner and pesticides, if you use them at all; improper use or disposal could contaminate the lake.
- Conserve electricity. Coal-burning power plants give off mercury, sulphur, and other chemicals which can damage aquatic ecosystems.
- Get involved! Join litter pick-ups and environmental groups that share your views.

EXTENSIONS

- Have students travel in pairs throughout the stations except when they go to the "clouds," where they break up and reform with other water molecules. This is what happens when water evaporates and then condenses again.
- Have students keep track of their movements, This can be done by having them keep a notepad to record each move they make, including stays. Another approach is to have half the class play the game while the other half watches. Partners can be assigned to track each other's movements.

ASSESSMENT

- Have students use their travel logs to write a story about the life of a water molecule including the specific elements of the hydrocycle in their stories.
- Have the class design a large mural showing where and how water moves from one location to another
- Have older students teach "The Incredible Journey" to younger students

This lesson adapted from Project WET: "The Incredible Journey."

Water Cycle Table (FOR "INCREDIBLE JOURNEY")

STATION	DIE SIDE LABELS	EXPLANATION
Soil	one side plant	Water is absorbed by plant roots
	one side river	The soil is saturated, so water runs off into the river
	one side groundwater	Water is pulled by gravity and filters into the soil
	two sides clouds	Heat energy is added to the water, so the water evaporates and goes to the clouds
	one side stay	Water remains on the surface
Plant	four sides clouds	Water travels through a plant via transpiration
	two sides stay	Water is utilized by the plant and stays in the cells
River	three sides Lake Superior	Water flows into Lake Superior
	one side groundwater	Water is pulled by gravity, it filters into the soil
	one side clouds	Heat energy is added to the water, so the water evaporates and goes to the clouds
	one side stay	Water remains in the current of the river
Clouds	one side soil	Water condenses and goes into the soil
	one side river	Water condenses and falls into the river
	three sides Lake Superior	Water condenses and falls into the Lake
	one side stay	Water remains as a water droplet clinging to a dust particle
Ocean	two sides clouds	Heat energy is added to the water, so the water evaporates and goes to the clouds
	four sides stay	Water remains in the ocean
Lake Superior	one side fish	A fish drinks the water
	one side ocean	Water flows through the other Great Lakes and St. Lawrence River to the ocean
	one side clouds	Heat energy is added to the water, so the water evaporates and goes to the clouds
	three sides stay	Water remains in Lake Superior
Fish	three sides Lake Superior	Water is excreted into the lake
	one side river	Fish travels up a tributary
	two sides stay	Water is incorporated into the body
Groundwater	one side river	Water filters into the river
	two sides Lake Superior	Water filters into the lake
	three sides stay	Water stays underground

Making Waves

Waves are a special part of Lake Superior, from the 30-foot high waves that can wreck a ship to the ripples that tickle your toes. Learn what waves do on and to the lake.

TOPIC
Waves and erosion.

AUDIENCE
Grades K-5, 15-30 students

LENGTH
40-60 minutes

GOAL
To understand that waves are a powerful force on Lake Superior.

OBJECTIVES
- *Students will try to visualize waves.*
- *Students will see how erosion works.*

MATERIALS
- *sound recording of waves (different sorts, if possible) and proper AV equipment for recording*
- *drawing paper*
- *parachute or long strips of cloth (optional)*
- *4-6 containers of sands, with lids (glass jars)*
- *15-20 sugar cubes*
- *piece of beach glass and freshly broken piece of glass*

BACKGROUND

See background information for this section.

GETTING READY

Prepare the materials as listed.

PROCEDURE

1. Introduction—sounds

Have students listen to the recording of wave sounds one time through. Discuss what they heard. What do they think it was? Hopefully most of them will believe they heard waves. Ask them to listen to it again, this time listening for what the waves are like. Talk about the different ways waves are made; storms, boats, gentle wind, people swimming. You can also talk about how waves sound different when they hit different types of shoreline. Examples are rock cliffs, pebbly shores, sand shores, ice, and marshy areas.

2. What does a wave look like?

Play the tape again, have them draw each type of wave they hear and what they think is causing it. An alternative to drawing is to have the students stand in a circle holding the parachute. As they hear the different sounds, have the group show by moving the parachute what type of wave they think it is. You can also use a long strip of cloth per student pair. One student stands on each end and they work together to create the waves.

3. What do waves do?

Waves make big changes occur in Lake Superior. We see waves on the surface, but they also affect the bottom as they reach the shore. Roll your hand over a collection of rocks and then over sand. Ask students what is making the noise? The rocks and sand rubbing against each other. What happens to the rocks and sand after years of being on a beach?

4. Erosion

Divide the students into groups of 3-5. Hand each group a container of sand and two sugar cubes. Tell them that this is an experiment to see how rocks can change shape and how sand is formed. Ask them for hypotheses or have them write them down. Also draw the cubes for a before and after series. When they are ready, have them put the cubes into the sand container and start shaking. You may have some groups shake rigorously and others shake slowly. Stop after 30 seconds and look at your cubes. Draw them. Shake again for 30 seconds, and continue shaking and checking every 30 seconds until the sugar has completely broken down.

Show the beach glass and compare it with a freshly broken piece of glass. Show also rough and smooth rocks. Ask students what caused these changes. The energy of the waves or the energy of the rock tumbler cause the movement and rubbing of the rocks.

EXTENSIONS

- Along with the lesson or on its own, set up a water table using a long container filled with water, sand, smooth rocks, and rough rocks. Allow the students to explore wave action and sounds on their own.
- Tumble agates or other stones. Students can draw "before" and "after" pictures. Between the two drawings they can draw the agent of change, the tumbler and sand in the tumbler.

A Bucket Full of Stories

Every Lake Superior rock tells a story, about fiery seas or ancient mountains, great valleys or sliding oceans. This lesson helps students hear, and tell, these stories.

TOPIC
Lake Superior geology.

AUDIENCE
Grades K-3, 15-30 students

LENGTH
30 minutes

GOAL
Students will understand the variety of rocks and be curious about Lake Superior's geological origins.

OBJECTIVES
- Students will be able to distinguish different characteristics of rocks, such as texture, color and hardness.
- Students will have the opportunity to imagine for themselves how rocks might have been formed.

MATERIALS
- bucket labeled "Stories," full of 1"-2" rocks from the Lake Superior watershed

BACKGROUND

Read the background material in the introduction to this section.

GETTING READY

Go to a Lake Superior cobblestone beach and gather a bucket full of rocks. Put these in a container and label it "Stories."

PROCEDURE

1. Introduction – Stories

Explain that everywhere you go there are stories. A leaf on the ground tells a story, so does a creek running through the woods. Explain that you went for a walk on the beach and collected "a bucket full of stories." Pull out the bucket of rocks. Shake the bucket a bit so the students can tell what's inside.

Pull out a rock. Ask "Can a rock tell a story?" Ask students to think of the stories they heard as a kid. How do they all begin? "A long time ago, in a land far, far away...." Well, each of these rocks has a story that begins the same way.

2. Looking at rocks

Before handing out rocks, explain that students are going to examine them with all their senses and try to find any stories the rocks might tell. Divide students into groups of three to five, and give each group a handful of rocks (5-7). Go around the room coaching students to examine the rocks. Ask questions individually like "is it rough or smooth?", "does it have many colors or just one?"

Once students have examined their rocks, ask for a volunteer to tell a story about their rock that begins "A long time ago, in a land far, far away, this rock..."

3. Dividing rocks

Explain that in order to figure out the stories of rocks, scientists learn to divide rocks into different categories. Ask the groups of students to divide their pile of rocks into two groups. Give them about five minutes to do this. Go around the room again coaching them.

Get the students' attention and go around to each group, asking what categories they used to divide their rocks. Write the categories on the board in two columns, e.g. "Rough" and "Smooth."

Once all the groups have spoken, have the different groups try to sort their rocks into two piles with the categories another group used.

4. Closure

Explain that this is exactly what geologists do when they find a rock—they go through a list of characteristics and decide what kind of rock it is. Explain that there are many kinds of rocks all around Lake Superior, and they all tell different stories.

ASSESSMENT

The students' ability to sort rocks according to another group's criteria will show how well they understand the concepts involved.

EXTENSIONS

- If the students do well at this exercise, have them take it a step further and divide their two piles into more piles based on other characteristics. Ideally this will lead to a dichotomous key, which can be called "the tree of rocks"–each branch represents a different sort of rock.
- Do this at a Lake Superior beach! Have students collect 2-3 rocks each, then get into small groups and do the exercise.

IN One Lake and OUT the Other

How does water flow in and out of Lake Superior? Or through the Great Lakes system? Learn how actions in one part of the Great Lakes affects the whole system through models, data recording and a large-group demonstration.

TOPIC
Lake Superior as the headwaters of the Great Lakes system.

AUDIENCE
Grades 5-8, adaptable for small or large groups

LENGTH
25 minutes

GOAL
To gain an understanding of how actions in one part of the Great Lakes system can affect many other areas.

OBJECTIVES
- Students will be able to describe how water moves through the Great Lakes system.
- Students will draw conclusions about how retention time affects the health of a lake and how the health of one Great Lake can impact another.

MATERIALS
- milk carton model of three of the Great Lakes; students can label the cartons "Lake Superior," "Lake Huron," and "Lake Erie."
- food coloring or India ink
- observation worksheet

BACKGROUND

This lesson focuses on the key facts that Lake Superior is the headwaters of the Great Lakes and that Lake Superior has a long retention time compared to most other lakes. Retention time is the number of years that a unit of water will take to pass through the lake. The retention time, however doesn't give a complete picture. When discussing pollution, it is the removal time that shows how long it will really take for 90% of the pollution to leave a lake. 90% of removal times can be calculated by multiplying the retention time by 3. In the case of Lake Superior, the 90% removal times would equal 191 x 3 = 573 years.

GETTING READY

Lakes model can be assembled using half-gallon, quart, and pint-sized cartons as in the diagram shown below.

PROCEDURE

PART A: MILK CARTON MODELS

1. What's happening?

Show the students the carton model. Explain that the model represents a system of lakes like the five Great Lakes. Have the students recall that Superior has the greatest volume, Erie the least, and recall that the lakes flow down in elevation as they flow toward the Atlantic Ocean. There are now locks between the lakes so that ships can make it through areas that would otherwise have been impossible to get

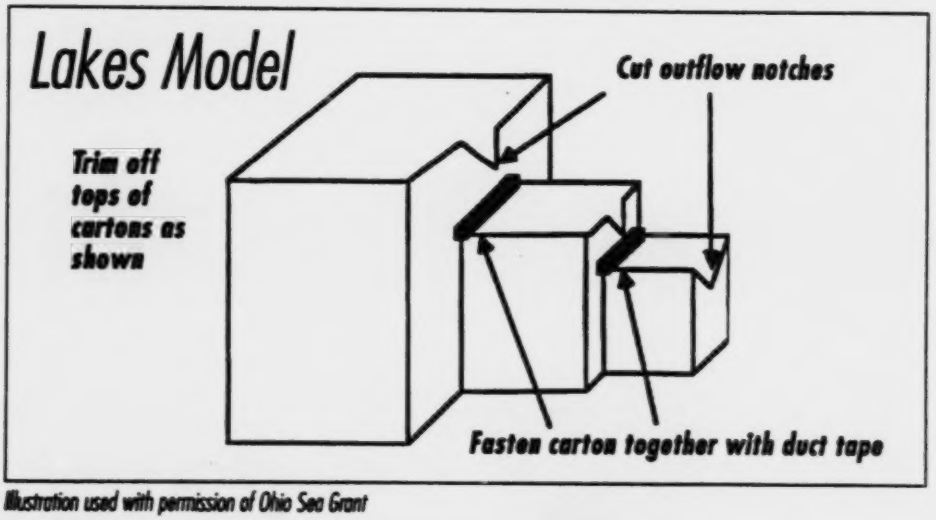

Illustration used with permission of Ohio Sea Grant

around, such as using the Welland Canal to go around Niagara Falls. The actual lake elevations (above sea level) are:

LAKE SUPERIOR	600 ft
LAKE HURON	577 ft
LAKE MICHIGAN	577 ft
LAKE ERIE	569 ft
LAKE ONTARIO	243 ft

2. Fill 'em up!

Fill the 3 cartons with water up to 1 inch from the top. Measure the water depth of each lake with a ruler and have a student record each an a piece of paper or blackboard.

3. Getting deeper

Add one cup of water to the largest lake and measure its depth. Record it. Do the same to the other two lakes- add one cup to each, measure, and record. What can the students conclude about how the volume of a lake affects changes in water levels?

4. Pollution

Add several drops of India ink/food coloring to the water in the largest lake and stir gently. What has happened to the color of the water?

5. Let it flow

Slowly add water to the largest lake until it begins to overflow into the middle lake. What is happening to the water in the middle lake? Continue adding water to the largest lake until the water is overflowing from each lake. Have the students describe what happens to the color of the water in each lake as more water is added to the system.

6. Clean up your act!

Continue adding water until the water in the largest lake looks clear again. Can you still see ink in the water of the other lakes? What can you conclude about how pollutants can be carried from one lake to the next?

How did the amount of time it took for the larger lake to appear clearly differ from the smaller lakes? The amount of time for a lake to completely replace its water is called "retention time."

PART B: RETENTION TIME DEMONSTRATION

1. Getting set

Have the students stand up. Divide them into 5 even groups. It's fine if the groups aren't all even. Name each group one of the Great Lakes and have them form a small circle linking hands with their lake members. Have all five circles line up according to how the Great Lakes flow down and out into the Atlantic (Superior, Michigan, Huron, Erie, and Ontario). This is not a perfect model but will help explain retention time. When they are lined up, have them join a hand with the next lake so they all connect.

2. Acting out

Explain that you will start a water molecule in Lake Superior and that each group will count out loud together up to the number of years that molecule will stay in their lake. They will pass it on by squeezing the hand of a person in the next lake. That lake group then counts out loud up to their number of years and then passes the molecule on to the next lake. Continue all the way through the 5 lakes. Tell each group their number of years

(retention time) by whispering to them. Groups should not know other groups' retention times until the game is under way.

	YEARS
LAKE SUPERIOR	191
LAKE HURON	22
LAKE MICHIGAN	99
LAKE ONTARIO	6
LAKE ERIE	2.8

Discuss the connections between the carton model and the line-up activity. How do they think retention time affects a lake? Does pollution stay where it started?

ASSESSMENT

- Students should list the lake route that water takes from the "headwater" lake (Superior) to the St. Lawrence Seaway.
- Ask students to create short play about a pollution molecule that starts out in Lake Superior.

EXTENSIONS

- *The Incredible Journey* activity works well as an introduction for this lesson. It prepares students for a discussion on how water moves into and out of the Lake Superior system.
- Instead of demonstrating with a single milk-carton model, have the students work in small groups and make their own models. Have them write the name of the lake on each carton as well as the volume, elevation, and retention time. Have them run through the demonstration in their small groups and write down their findings.
- Go back to the carton model and drop the India ink in the small lake first instead of the large. Still pour the water into the large lake or try pouring it directly into the small lake.
- Discuss what these models represent well and what they don't represent well. What makes sense using them and what doesn't?

REFERENCES

Statistics from U.S. Environmental Protection Agency.

Lesson adapted from "In One Lake and Out Another" in Paddle-to-the-Sea Supplemental Curriculum Activities and premiered by Superior, Wisconsin high school students.

More Than Just a Lake!

By creating a map of the rivers flowing into Lake Superior, learn how rivers form a watershed.

TOPIC
The Lake Superior drainage basin.

AUDIENCE
Grades 1-6, 10-30 students

SETTING
Large, open indoor space is required.

GOAL
To understand the concept of a drainage basin or watershed, and how that concept relates to the Lake Superior watershed.

OBJECTIVES
- *Students will understand the defining role that rivers have in watershed identity.*
- *Students will be able to state whether they live inside or outside of the Lake Superior drainage basin.*
- *Older students will be able to identify the river drainage basin in which they live.*

MATERIALS
- *large floor map of Lake Superior (or an outline on the floor made with masking tape, large enough for an entire classroom to sit around)*
- *10-15 short lengths (2-3 feet) of blue yarn*
- *ball of yarn colored other than blue, at least 50 feet long*
- *Minnesota, Wisconsin, Michigan and Ontario maps or a detailed North American atlas*

BACKGROUND

All lakes and rivers have a set area of land that water drains from, called the "watershed" or "drainage basin." Lake Superior has a relatively small drainage basin for its size; the Lake covers about 31,000 square miles (82,000 square kilometers) of a total watershed of about 81,000 square miles (210,000 square kilometers). See Lake Superior Watershed Fact Sheet for additional information.

Drainage basins are important environmentally because whatever happens within the basin of the lake can happen to the lake itself. Toxic substances spilled or placed on the land or in watershed rivers can end up in the lake.

PROCEDURE

1. Introduction

Students gather around the "shore" of the lake. Explain that the blue yarn represents rivers. With younger students, demonstrate how one river might look on the map as it flows into Lake Superior.

2. Laying out the rivers

Give each pair of students a piece of blue yarn. Younger students place their "river" somewhere on the map where it flows into the lake. Make sure that they do end at the lake. Ask some students questions about their rivers, e.g. "Any waterfalls?," or "How's the fishing?"

Older students should be given a Lake Superior river card (See river names at end of lesson). Students will have to use a Lake Superior map, highway maps, or an atlas in order to locate their river. Once a student, or a pair of students, has found their river, they should "map" it—by placing their blue yarn in connection to the map, to model the actual river flow to the lake.

3. The boundary

Once all the rivers are in place, explain that the students will now create an imaginary line. Standing near one of the "rivers," ask "If a raindrop falls here, where will it go/drain?" (to the lake). Then, standing away from the river, ask the same question (it goes somewhere else, like Hudson Bay or down the Mississippi). So there is a line that separates the places where water will fall and drain into Lake Superior from the places where water will fall and drain somewhere else. Use a ball of yarn to mark this boundary; walk around the lake with the yarn asking students to hold the yarn at the top of their rivers.

4. Implications

For the younger students explain that they have created a model of what a watershed looks like. Show them a picture of the actual watershed, discuss

how their model is similar to the actual. Ask the students if their school falls inside or outside of the Lake Superior Watershed.

With the older students, explain that their map marks a close approximation of the Lake Superior drainage basin. Is their school inside or outside the drainage basin? If outside the basin, what drainage basin is it in? Could dumping something on the ground here affect Lake Superior? If not, what would it affect?

EXTENSIONS

- Give older students a map of the actual rivers of the Lake Superior basin and have them duplicate the tributaries and branches of the Lake Superior rivers.
- Discuss associated environmental issues, such as the concept of an "airshed" (the area from which the lake draws airflow and thus air pollutants) and the potential demand for pumping water out of Lake Superior for the arid southwest.
- Use the Lake Superior Watershed fact sheet to create comparisons, mathematical studies, etc..

ASSESSMENT

- Ask students if they live in the Lake Superior Watershed.
- Ask students what other watersheds they live in.

ST. LOUIS RIVER	FRENCH RIVER
BAPTISM RIVER	PIGEON RIVER
KAMINISTIQUIA RIVER	NIPIGON RIVER
PIC RIVER	MICHIPICOTEN RIVER
NEMADJI RIVER	BRULE RIVER
ONTONAGON RIVER	BIG TWO HEARTED RIVER
MONTREAL RIVER	PRESQUE ISLE RIVER
STURGEON RIVER	

Lake Superior Watershed Fact Sheet

Lake Length — 350 mi (563 kilometers)
Lake Breadth — 160 mi (257 kilometers)
Lake Depth — 483 ft (147 m) average • 1333 ft (405 m) maximum
Volume — 2900 cubic mi (12,100 cubic kilometers) Enough to cover North, Central, and South America with one foot of water.
Water Surface — 31,700 square miles (81,103 square kilometers)
Watershed Area — 81,000 square miles (209,000 square kilometers)
% of watershed covered by lake — 39%
Shoreline length — 2726 mi (4385 kilometers)
Water Retention Time — approximately 191 years
Average Water Temperature — approximately 40° F (4.4 °C)
Average Winter Ice Cover — 60%
Number of Tributaries — 336

RIVER NAME AND AREA DRAINED

1. Nipigon (ONT) — 14,900 square miles (38,202 square kilometers)
2. Aguasabon (ONT) — 4482 square miles (1,492 square kilometers)
3. St. Louis (MN) — 3432 square miles (880 square kilometers)
4. Kaministikwia (ONT) — 2525 square miles (6475 square kilometers)
5. Michipicoten (ONT) — 2090 square miles, (361 square kilometers)
6. Pic (ONT) — 1666 square miles, (273 square kilometers)
7. Ontonagon (MI) — 1353 square miles (470 square kilometers)
8. Montreal (ONT) — 1111 square miles (2849 square kilometers)
9. Tahquamenon (MI) — 798 square miles (2046 square kilometers)
10. Sturgeon (MI) — 710 square miles (1820 square kilometers)
11. Bad (WI) —620 square miles (1570 square kilometers)
12. Pigeon (MN/ONT) — 606 square miles (1554 square kilometers)
13. Little Pic (ONT) — 515 square miles (1321 square kilometers)
14. Batchawana (ONT) — 464 square miles (1189 square kilometers)
15. Presque Isle (MI) — 262 square miles (673 square kilometers)
16. Montreal (WI/MI) — 262 square miles (670 square kilometers)
17. Black (MI) — 202 square miles (518 square kilometers)
18. Bois Brule (WI) — 140 square miles (360 square kilometers)
19. Iron (MI) — 101 square miles (260 square kilometers)
20. Sand (WI) — 38 square miles (98 square kilometers)

Weathering Lake Superior

How's the weather? If you're close to Lake Superior, chances are it's different than the weather inland. Explore weather and climate via a Lake Superior basin temperature study.

TOPIC
Lake Superior's impact on air temperature.

AUDIENCE
Grades 4-8, 3-30 students

LENGTH
Variable: 2-4 hours

GOAL
To understand that the great body of Lake Superior water has a profound impact on air temperature; and that air temperature, as a part of climate, has an impact on human behavior.

OBJECTIVES
- *Students will be able to describe the moderating effect lake Superior has on air temperature.*
- *Students will be able to define Lake Superior as both a heat source and heat sink.*

MATERIALS
- *Lake Superior Watershed Map*
- *temperature data*
- *table lamp*
- *4 thermometers*
- *2 matching, large containers—small aquariums work well, one 3/4 full with soil, and the other equally full with water*
- *colored pencils*
- *graph paper*
- *2-4 rulers*

BACKGROUND

A body of water such as a lake acts much the same as the water of this experiment. During the day the water of a lake is a heat sink, storing up heat from the atmosphere. At night, it becomes a heat source, giving up heat throughout the night. If you live near a lake you have experienced land sea breezes which are caused by the lake. Lake water tends to increase in temperature all summer. This indicates that it is storing up extra energy from the atmosphere. It acts as a heat sink throughout the summer. In the autumn and winter, however, there is less radiation from the sun. Lakes then become heat sources giving up their energy to the atmosphere.

See introductory background information for more details.

GETTING READY

See Parts A and B.

PROCEDURE

1. Introduction

Engage students in a "warm-up" temperature discussion, potential questions include:

- Why is it that lakes don't immediately freeze over when our air temperatures dip below 0°C (32°F)?
- Why do we witness steam rising from Lake Superior on cold days?
- Why is it that on hot May days, when we are eager to jump in a lake and cool off, we are often stopped by extremely cold water?
- Why is it that air temperature and water temperature don't often match?

Ask students if they think that Lake Superior has an impact on the air temperature around it (if students live on the lake or in the basin, ask them specifically about their community or region). Create a hypothesis with students. This hypothesis can later be revisited.

PART A: HEAT SINK, HEAT SOURCE

GETTING READY

Set up the "Heat Sink, Heat Source" experiment in the following arrangement. (This works well as a science station, with cooperative learning groups working together to collect the necessary data.)

- Place the containers of earth and water about 3 centimeters apart.
- Attach one thermometer above the water, with another suspended in the same fashion above the soil.
- Place one thermometer in the soil with the bulb just barely covered, the thermometer can be attached to an upright ruler for stability. Place

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another ruler similarly positioned in the water (suspended from a ruler that is bridging the container).

- Position the lamp 30 centimeters above and centered between the containers. Be sure that the the bulb of each thermometer is shielded from the direct rays of the lamp.

1. Start experiment

- Provide a data table for each student/ group of students, or make one available for students to copy into their notebooks.
- Make sure that all of the thermometers are recording the same temperature at the start of the students' observations. (If the students' thermometers do no read the same at the beginning, then the readings should be adjusted so that the initial readings are equal. This can be done by finding the lowest reading and the difference between it and all of the others. The difference for each of the others is then subtracted from each reading given by the thermometer.

2. Discussion of experiment and questions

The following is information to help facilitate the discussion of the student questions:

- Air heats up faster over the soil.
- While the lamp is on, the soil should be heating up more rapidly than the water since soil has a lower specific heat and it absorbs all radiation close to the surface. Specific heat is the amount of heat (in calories) required to raise the temperature of one gram of substance by one degree Celsius. The specific heat of water is 1. For all other common liquids and solids the specific heat is less than 1.
- After the light is turned off, the soil should cool more rapidly than the water because of its lower specific heat.
- Water will absorb more energy. The air over the soil heats up much more rapidly than that over the water. This is because soil cannot hold unto heat energy and gives it right back to the atmosphere. Water will eventually act as a source of heat for the atmosphere.
- Soil loses heat faster than water.
- Water keeps its energy the longest.

Anything that adds heat energy to the atmosphere is called a heat source. A heat sink takes energy from the atmosphere. Thus, discuss the following:

Could soil or water be considered a heat source or sink when the light was on?...light off?

3. A Lake Superior puzzler

Based on the experiment, questions, graphing and discussion, can you explain why it is that the temperatures of Lake Superior water reach their average warmest temperatures in late August each year? The coldest waters are, on average, observed in March! The yearly mean lake temperature is approximately 40° F (4.4° C).

Heat Sink, Heat Source Student Worksheet

STUDENT DATA TABLE:

Time elapsed	*Thermometer 1 above soil*	*Thermometer 2 in soil*	*Thermometer 3 above water*	*Thermometer 4 in water*
1 min.				
2 min.				
3 min.				
4 min.				
5 min.				
6 min.				
7 min.				
8 min.				
9 min.				
10 min.				
11 min.				
12 min.				

STUDENT INSTRUCTIONS FOR EXPERIMENT

1. Turn the lamp on and at each one minute interval record the temperature indicated on each of the four thermometers. Continue this for 12 minutes.
2. Turn the lamp off. Continue recording temperatures at one minute intervals for 12 minutes.
3. Graph the data that you have collected. "Temperature" can be graphed along the X axis, and "time elapsed" along the y axis. Be sure to use different colors for the four variables and label them in a key.
4. Question: Does the air heat up faster over the soil or over the water when the light is on?
5. Question: With the light on, which changes more, the temperature of the soil or the temperature of the water?
6. Question: Which absorbs more energy, soil or water?
7. Question: With the light off, which changes more, the temperature of the soil or the water?
8. Question: With the light off, which changes more, the temperature above the soil or above the water?
9. Question: Which loses heat faster, soil or water?
10. Question: Which keeps heat energy the longest, soil or water?

PART B: TEMPERATURE DATE

GETTING READY

The charts on the next page contain National Oceanic and Atmospheric Administration Temperature data averaged during the period 1961-1990. They can be copied for cooperative learning groups or made into overhead projections for whole class use. All three Lake Superior States can be used, or a class study might be limited to one specific state.

1. Discuss the data

What information are they providing? Where do we see the warmest January temperatures? The coldest? Where do we see the hottest and coolest July temperatures? Challenge the students to use the terms "heat sink" and "heat source" as they describe the isotherm map information.

Lake Superior is both a heat source and a heat sink depending on the season. In the late spring and summer, it is a heat sink, but in the fall and winter it is a heat source. Lake Superior acts as a moderator for lakeshore climate. It keeps the air cooler in the early summer and warmer in the fall and winter.

The information can be used for graphing, for creating isotherms, etc. The numbers provided are the mean maximum and minimum daily temperatures. Mean daily temperatures are computed by summing the daily maximum and minimum temperatures and dividing by two. The sum of the daily mean temperatures are recorded for an entire month and then divided by the number of days in the month. This provides the mean monthly temperature. It should be noted, in case students ask, that the maximum and minimum temperatures are recorded by special thermometers housed in a standard instrument shelter. There exists a network of weather stations in both the U.S. and Canada.

2. Impact on people

Ask students to think about how lake-influenced weather effects human behavior. Using the following "equation" try to find examples that "work":

Lake + Weather = human behavioral adaptation

The following description illustrates the equation:
Lake Superior modifies the temperatures around its shores. Spring cool weather often prevents premature budding of sensitive fruit trees, lessening the chances of a late spring frost killing the buds. Slow cooling of Lake Superior often pushes back the date of the first fall frost, which serves to extend the growing season. The Bayfield Wisconsin area is known for its delicious and bountiful apple harvest.

ASSESSMENT

Observation of student participation and understanding in discussion can serve as an effective assessment for this lesson.

EXTENSIONS

- Contact the National Oceanic and Atmospheric Administration, or Lake Superior Center for average precipitation data and conduct a study of the impact Lake Superior has upon watershed precipitation.

MINNESOTA MEAN MONTHLY DATA FOR JULY AND JANUARY *in degrees Fahrenheit*

COMMUNITY	JANUARY MAX./MIN.	JULY MAX./MIN
International Falls	11.9/-10.0	78.8/54.6
Grand Marais	22.2/3.9	70.5/52.1
Duluth Harbor	19.3/2.9	74.3/58.3
Cloquet	17.9/-2.5	80.8/54.1
Two Harbors	22.0/3.4	75.5/53.3

DULUTH COMPARISON DATA

(HARBOR=LAKESHORE, AIRPORT=AWAY FROM LAKE), MONTHLY MAX. AND MIN. AVERAGED:

Location	J	F	M	A	M	Jn	Ju	A	S	O	N	D
Harbor	11.1	16.2	27.0	38.5	48.1	57.4	66.3	65.4	57.3	47.0	32.5	17.5
Airport	7.0	12.3	24.4	38.6	50.8	59.8	66.1	63.7	54.2	43.7	28.4	12.8

WISCONSIN MEAN MONTHLY DATA FOR JULY AND JANUARY *in degrees Fahrenheit*

COMMUNITY	JANUARY	JULY
Bayfield	20.7/1.7	78.4/55.5
Solon Springs	18.7/-5.5	82.4/54.7
Madeline Island	20.6/2.8	77.0/54.2
Spooner	20.8/-1.6	82.1/56.8
Winter	18.1/-5.1	78.2/53.3

MICHIGAN MEAN MONTHLY DATA FOR JULY AND JANUARY *in degrees Fahrenheit*

COMMUNITY	JANUARY	JULY
Sault Ste. Marie	21.1/4.6	76.3/51.3
Ironwood	18.7/-1.3	77.9/54.6
Grand Marais	25.3/11.2	75.9/51.9
Munising	23.9/7.5	76.2/53.6
Crystal Falls	20.4/-2.4	78.6/51.2

This lesson has been adapted from "The Effect of the Great Lakes on Temperature," Ohio Sea Grant, and includes National Oceanic and Atmospheric Administration Climate Data.

Superior Lakewatch

How can citizens help protect and understand something as big as Lake Superior? Just a thing called a Secchi disk and a lot of love.

TOPIC
Using data from an actual water clarity volunteer monitoring program on Lake Superior to focus on describing scientific data study.

AUDIENCE
High school math/science students (can be adapted for younger students).

LENGTH
1-3 class periods

GOAL
Students will practice applying math skills and be introduced to citizen stewardship.

OBJECTIVES
- *Students will use math skills to describe, analyze, and present scientific data.*
- *Students will realize that it is possible to protect and study ecological systems even if you are not scientists or politicians.*

MATERIALS
- *Superior Lakewatch raw data*
- *Secchi disk*

BACKGROUND

Environmental monitoring by volunteers has increased greatly in the last twenty years. Today, in Canada and the United States there are hundreds of volunteer programs and thousands of volunteers.

In the mid-1980s it became clear that there was a need for citizen monitoring of Lake Superior. First of all, it is an incredible natural resource, holding 10% of the world's liquid surface freshwater. Secondly, because of the lake's international shoreline, it is not clear which agency should do what monitoring. Thirdly, the lake's size makes it very expensive for agencies to monitor. And finally, long-term data collection is essential to the conservation of our aquatic resources. Responding to these needs, a group of scientists and volunteers started Superior Lakewatch in 1991.

Superior Lakewatch is an international, citizen-based lake monitoring program that seeks public involvement with Lake Superior. Superior Lakewatch volunteers collect baseline information on Lake Superior's water clarity as an indicator of water quality. Data collected through the program is made available to scientists, policy makers and the public with the goal of protecting Lake Superior.

The tool we use for monitoring is called a Secchi disk. It provides a simple visual index of water clarity—which is closely tied to water quality. An observer lowers the disk into the water until the disk can no longer be seen, and then raises it just enough so it comes into view again. The depth at reappearance is the Secchi reading, and the volunteer records this on the provided data sheet.

Secchi disks operate on a simple principle: the depth of reappearance of the Secchi disk is inversely proportional to the average amount of organic and inorganic material along the path of sight in the water. The dominant light blocking (or "attenuating") materials in Lake Superior are eroded silt or clay, and algae. Some of the red clay in the lake is natural because the watersheds have fine grained materials in them. But natural erosion is often accelerated by inappropriate development in the watershed.

Algae attenuate light in two ways: by the fact that they are particle, and by the fact that they have chlorophyll and other light-gathering pigments. Therefore the Secchi disk has the potential both to detect erosion in the watershed and determine relative amounts of algae.

There are now over 50 Superior Lakewatch volunteers including fishermen,

recreational boaters (in sailboats, powerboats and kayaks), national park personnel, Department of Natural Resources fishery specialists and dive boat captains. It is an effort to protect the natural beauty of the ecosystem. A goal which is being accomplished with the assistance of the citizenry of Lake Superior. The citizens involved become catalysts for leadership at the community level, leadership which supports a healthy Lake Superior.

For more information on this topic see "Water Clarity and the Secchi Disk" in the introductory section.

PROCEDURE

1. Introduction

Using the background information, introduce students to Superior Lakewatch, the Secchi disk and the concept of citizen monitoring and stewardship.

2. Mean values

Hand out raw data to students and explain how math skills are useful to describe, analyze, and present scientific data. Explain, as an example, that Lakewatch has accumulated 1233 good readings (still useful after quality control procedures) in the first four years of sampling. If we only give someone a copy of all the data, it would be a very long and confusing list. Instead, we organize the data using descriptive statistics. The 1233 readings can be expressed like this: "The Secchi transparency readings on Lake Superior between 1991 and 1994 (n=1233) have a mean value of 24 feet and a standard deviation of 6 feet."

3. Analyze trophic states

One concept that is useful for analyzing Secchi disk transparency readings is called the trophic state index, which was developed by Dr. Robert Carlson. It is an empirically-developed mathematical formula which is used to describe lake water quality using Secchi disk transparency measurements.

The first step that needs to be done with the Superior Lakewatch data is to convert the measurements from feet to meters. Next, use the following formula:

$$\text{Trophic State Index } TSI = 10\left(6 - \frac{\ln SD}{\ln 2}\right)$$

SD is the Secchi disk reading in meters; "ln" is the natural log.

If the TSI < 40 the Lake is oligotrophic, meaning clear water and good oxygen saturation, and small levels of algae. If the TSI is between 40 and 60, the lake is mesotrophic, the water is less transparent, and algal populations are larger. If the TSI > 60 the lake is eutrophic, meaning that water transparency is very low due possibly to large populations of nuisance algae.

Based on this information, which of the Superior Lakewatch data below reflect an oligotrophic lake? Which mesotrophic? Any eutrophic readings?

4. Graphing

Every picture tells a story. A graphical representation of data is another excellent way of taking long columns of confusing data and clarifying it . Lake data is often graphed in quadrant 2. The x-axis represents the lake surface and the y-axis represents depth of water (see Figure 1). When graphing Secchi transparency data you can choose bar graphs which denote that each measurement is distinct, and even though you know that transparency

went from 12 feet to 18 feet you do not know whether it went from 12 feet ->25 feet->18 feet or 12 feet->6 feet->18 feet. When stressing trends, however, a line graph often is more visually interesting. It's your choice.

5. Do It

Use the Secchi disk to sample Lake Superior or another lake from a boat or pier.

6. Closure

Have students prepare a report which discusses the importance of citizen monitoring and uses math skills to describe, analyze and graph their data.

EXTENSIONS

- Study the physics of light transparency in water and how this relates to the Secchi disk.
- See "What is a Lake?" lesson in this guide (also available in Lake Superior Ecosystem Learning Kit) to study lake functioning and monitoring in greater detail.
- For more specific information or additional data for use, contact Superior Lakewatch at Lake Superior Center.

REFERENCES

Carlson, R.E. 1977. *A trophic state index for lakes.* Limnology and Oceanography 22(2): 361-369.

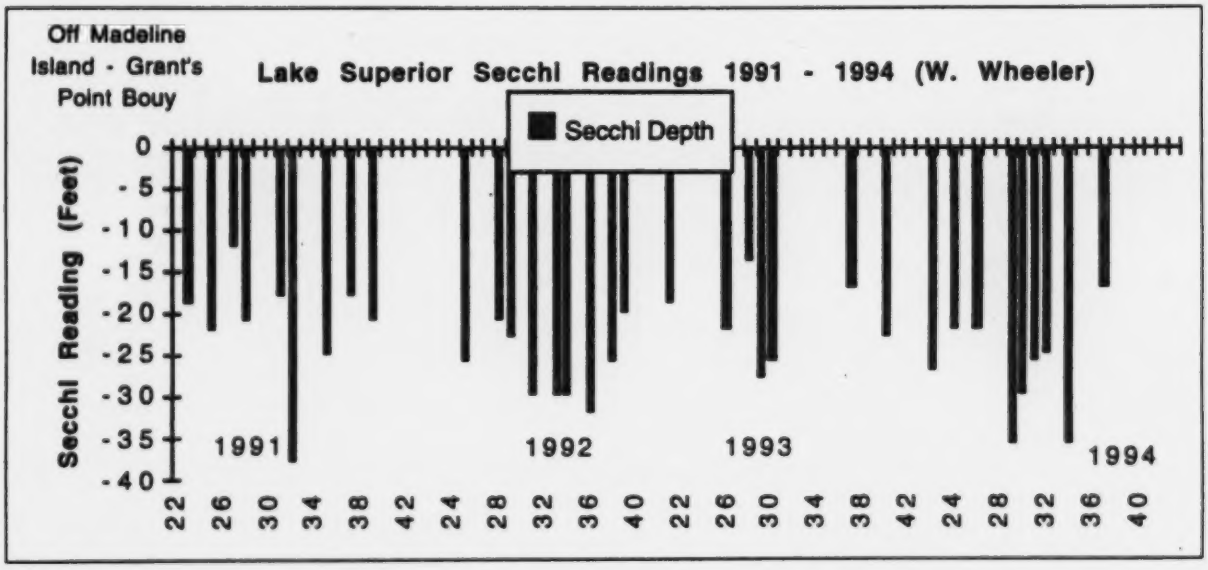
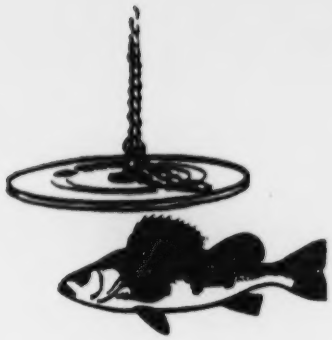


Figure 1:
An example of how to graph Secchi disk transparency data.

Superior Lakewatch Data Table



Data from Superior Lakewatch volunteer Bill Wheeler

Off Madeline Island at Grant's Point Bouy

Latitude: 46.74 degrees North

Longitude: 90.8 degrees West

Year	Week	Month	Day	Time	Secchi depth (ft.)
1991	23	6	5	1030	-19
1991	25	6	16	1115	-22
1991	27	7	5	1025	-12
1991	28	7	13	1115	-21
1991	31	7	27	1215	-18
1991	32	8	10	1415	-38
1991	35	8	25	1440	-25
1991	37	9	10	1530	-18
1991	39	9	24	1245	-21
1992	25	6	21	1130	-26
1992	28	7	6	1150	-21
1992	29	7	17	1345	-23
1992	31	8	2	1115	-30
1992	33	8	14	1435	-30
1992	34	8	18	1540	-30
1992	36	9	1	1510	-32
1992	38	9	15	1430	-26
1992	39	9	27	1107	-20
1992	43	10	22	1520	-19
1993	26	6	28	1645	-20
1993	28	7	10	1240	-14
1993	29	7	21	1415	-28
1993	30	7	30	1030	-26
1993	37	9	18	1133	-17
1993	40	10	5	1055	-23
1994	22	5	30	1040	-27
1994	24	6	12	1230	-22
1994	26	7	2	1340	-22
1994	29	7	17	1030	-36
1994	30	7	24	1200	-30
1994	31	8	3	1435	-26
1994	32	8	10	1600	-25
1994	34	8	22	1625	-36
1994	37	9	17	1400	-17

SUITABLE CONDITIONS:
• BETWEEN 10 A.M. & 4 P.M.
• RELATIVELY CLEAR
• RELATIVELY CALM (NO WHITECAPS)
• COAST GUARD APPROVED SAFETY EQUIPMENT
• TIE SECCHI DISK TO THE BOAT
① LEAN SLIGHTLY OVER SHADY SIDE OF BOAT. LOWER UNTIL DISK CAN'T BE SEEN.
② SLOWLY RAISE DISK. WHEN DISK APPEARS, THIS IS THE SECCHI DISK READING
THE SECCHI DISK IS USED TO MEASURE THE LAKE'S TRANSPARENCY— AN IMPORTANT INDICATOR OF OVERALL WATER QUALITY.

Examining The Great Lakes: A unit of four activities

A series of four activities that examine Lake Superior and some common misconceptions of the Great Lakes. Conduct a survey. Draw a profile of Lake Superior. Compare the depth, area and volume of the Great Lakes. Compare other "Great Lakes."

ACTIVITY 1 - WHADDYA KNOW?

ACTIVITY 2 - DEPTH SOUNDINGS

ACTIVITY 3 - TAKING IT PERSONALLY

ACTIVITY 4 - BIG LAKE, BIG BASIN?

These activities were designed to be used sequentially but can be used on their own if you provide the necessary materials.

TOPIC
Profiles, misconceptions, comparisons, and data charts about the Great Lakes.

AUDIENCE
Grades 7-12

LENGTH
Activity One, the survey, must be done overnight because the students must talk to people outside the class.
The remainder of the activities take about 45 minutes each.

UNIT GOAL
Students will gain a higher appreciation of the value of Lake Superior by learning more information about the physical characteristics of the lake.

Whaddya Know?

(ACTIVITY ONE OF "EXAMINING THE GREAT LAKES" UNIT)

What do you know about the Great Lakes? What do you think you know? Students will initially answer some questions about the Great Lakes without using any sources, then ask the same questions of people outside the class. See how their answers compare!

TOPIC
Knowledge of and misconceptions about Lake Superior and the other Great Lakes.

AUDIENCE
Grades 7-12, 15-30 students

LENGTH
45 minutes, plus some time outside the classroom to conduct the survey.

GOAL
To realize there are many misconceptions regarding the Great Lakes, and that it is not hard to find the true information and make that known.

OBJECTIVES
- *Students will identify their perceptions of the size of the Great Lakes.*
- *Students will recognize some of the pitfalls of conducting surveys.*
- *Students will analyze data.*

MATERIALS
- *survey questions (one copy per student of both surveys and the analysis form)*
- *people outside of class to survey*

BACKGROUND

Students may be surprised by the amount of knowledge that people have or don't have regarding the Great Lakes. Here is a chance for them to talk to people about the Great Lakes and find out how much knowledge they do have. For more information on the physical characteristics of the lake, see the introduction to *The Physical Lake Superior.*

GETTING READY

Make copies of the survey for students.

PROCEDURE

1. Students take preliminary survey

Have students answer the questions in the preliminary survey without looking up information in a textbook or any other reference. Discuss the results with the class by going through the survey one question at a time and clarifying what the correct answer is.

2. Students survey others

Ask each student to survey ten other people not in your class about their perceptions of the Great Lakes, using the public survey.

3. Analysis

Have students use the Analysis of Survey Responses form to consolidate their data. Students should then compare their individual results to the results of others in the class.

ASSESSMENT

- Observe to see if the students are active and participating when comparing results with their classmates.
- Have students turn in the worksheets when completed to measure their level of understanding.

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Whaddya Know? Preliminary Survey

NAME_____ DATE_____

Answer the following questions without looking up the answers in a textbook or any other reference.
Use one of the Great Lakes for each of the answers. The choices are ***Superior, Michigan, Erie, Ontario and Huron.***

1. Which of the five Great Lakes is the largest?_____

2. Which lake has the most shoreline?_____

3. Which lake drains the fastest?_____ Slowest?_____

4. Which lake is the deepest?_____ Shallowest?_____

5. What two lakes drain into Lake Huron?_____

6. Which lake has the highest elevation above sea level?_____

7. Which lake does not border Canada?_____

8. Which lake holds the most water?_____

9. Which lake has the smallest surface area?_____

10. If we were to take ore ships that were one thousand feet long and stand them end to end in the deepest part of the lake, how many ships would be under water in Lake Superior?_____
Michigan?_____ Huron?_____ Erie?_____ Ontario?_____

11. About how far would a ship have to travel to get from Duluth, MN to the Atlantic Ocean?
a. 360 miles
b. 800 miles
c. 1560 miles
d. 2300 miles
e. 5300 miles

Whaddya Know? Public Survey

Ask ten people not in this class the following questions about the Great Lakes. Record their answers in the data table below. Use the codes below the graph for their answers. For "E" ask respondents to write their question on the back or on a separate sheet of paper.

SURVEY RESPONSES

WHICH OF THE GREAT LAKES:

	1	2	3	4	5	6	7	8	9	10
A *Is the largest?*										
B *Does not border Canada?*										
C *Is the smallest?*										
D *Is farthest away from where you live?*										
E *Write your own question that interests you on a provided comment sheet.*										

*Superior = **S**, Michigan = **M**, Huron = **H**, Erie = **E**, Ontario = **O***

When conducting a survey, it is important to remember these suggestions so that you get good responses.

- *Be polite. Ask the person if they would be willing to take part in a short survey. Give them an idea of how long the survey will take.*
- *Do not give any hints about the answers. "Good Responses" does not mean correct answers, but honest answers given without your influence.*
- *Thank the person for taking part in the survey!*

Whaddya Know? Analysis of Survey Responses

1. What are the correct answers to each of the survey questions?

A = _____ B = _____ C = _____ D = _____ E = _____

2. How many correct answers were given by the people surveyed for each of the questions?
(Example: if seven people out of ten got question B correct, B = 7)

A = _____ B = _____ C = _____ D = _____ E = _____

3. How many of the people surveyed got all five questions correct?

4. Compare your results to the results of 4 classmates. Complete the table below.

*Classmate name*_____ *Results from number 2 above:*

A = _____ B = _____ C = _____ D = _____ E = _____

*Classmate name*_____ *Results from number 2 above:*

A = _____ B = _____ C = _____ D = _____ E = _____

*Classmate name*_____ *Results from number 2 above:*

A = _____ B = _____ C = _____ D = _____ E = _____

*Classmate name*_____ *Results from number 2 above:*

A = _____ B = _____ C = _____ D = _____ E = _____

5. Make two observations from your table in question four.

6. How could your survey be improved to get more valuable information?
List at least three specific improvements.

Whaddya Know? Preliminary Survey KEY

Use one of the Great Lakes for each of the answers. The choices are ***Superior, Michigan, Erie, Ontario and Huron.***

1. Which of the five Great Lakes is the largest? SUPERIOR

2. Which lake has the most shoreline? HURON

3. Which lake drains the fastest? ERIE *(2.6 years retention time)*
Slowest? SUPERIOR *(191 years retention time)*

4. Which lake is the deepest? SUPERIOR *(483 ft average depth)* ***Shallowest? ERIE*** *(62 ft average depth)*

5. What two lakes drain into Lake Huron? SUPERIOR and MICHIGAN

6. Which lake has the highest elevation above sea level? SUPERIOR *(600 ft)*

7. Which lake does not border Canada? MICHIGAN

8. Which lake holds the most water? SUPERIOR *(2,900 cubic miles)*

9. Which lake has the smallest surface area? ONTARIO *(18,960 square kilometers)*

10. If we were to take ore ships that were one thousand feet long and stand them end to end in the deepest part of the lake, how many ships would be under water in
Lake Superior? 1 SHIP *(1,332 ft max depth)*
Michigan? 0 SHIPS *(925 ft max depth)*
Huron? 0 SHIPS *(750 ft max depth)*
Erie? 0 SHIPS *(210 ft max depth)*
Ontario? 0 SHIPS *(800 ft max depth)*

11. About how far would a ship have to travel to get from Duluth, MN to the Atlantic Ocean?
a. 360 miles
b. 800 miles
c. 1560 miles
d. 2300 miles ***(2342 actual miles)***
e. 5300 miles

Depth Soundings

(ACTIVITY TWO OF "EXAMINING THE GREAT LAKES" UNIT)

Is Lake Superior a deep lake? Well, yes and no. Students read the depth sounding from a Lake Superior chart and draw a graph that shows how wide the lake is compared to its depth.

TOPIC
The depth profile of Lake Superior.

AUDIENCE
Grades 7-12, 15-30 students

LENGTH
30- 45 minutes

GOAL
To visually experience a graphical representation of the bottom of Lake Superior and realize that the lake has a very gradual slope.

OBJECTIVES
- *Students will read depth soundings off of a Lake Superior chart.*
- *Students will create a graph that will accommodate the large length of Lake Superior along with its shallow (relative to length) depth.*
- *Students will recognize that the traditional profile of the Great Lakes has a greatly exaggerated depth to length scale.*

MATERIALS
- *Lake Superior chart with depth soundings*
- *graph paper with a very small scale, such as 20 boxes/inch*
- *rulers*
- *calculators*
- *tape*

BACKGROUND

Is Lake Superior a deep lake? Well, yes and no. It's one of the ten deepest lakes in the world, with an average depth of 500 feet (160 meters) and a deepest point of 1330 feet (430 meters)—deep enough to sink the tallest skyscraper in the world. Yet when you compare its vast surface area to its depth, it appears to be relatively shallow. The perception of Lake Superior as a deep lake is due both to the fact that it is deep, in comparison to the other Great Lakes, but also to the common use of a greatly exaggerated scale in profiles of the Great Lakes. When one understand the reality of Lake Superior's vast surface area, one is more likely to understand the role of atmospheric deposition of pollutants, as well as other important factors in the ecology of the lake.

GETTING READY

Obtain a good Lake Superior chart with depth soundings. Two charts that work well are the National Oceanic and Atmospheric Administration Lake Superior Chart #14961 and the Canadian Chart 4C 2300. Both charts are available at map and marine supply stores (available in Duluth at A&E Supply Co. and Marine General). These charts are also available for use from Lake Superior Center.

PROCEDURE

1. Introduction

Discuss the idea of a "depth profile." A depth profile can be described as a cross-section showing a lake's depth along a transect drawn across the length of a lake. Show the students a chart of Lake Superior.

Great Lakes Depth Profile

Ask for a volunteer to draw on the chalkboard a transect of what they believe to be the depth profile of Lake Superior. Ask the student how he/she came up with that depth profile. Show students the profile of the Great Lakes (diagram below can be enlarged and put on a transparency). Explain the numbers on the chart concerning length, depth, and lake elevation. Be sure to establish whether the chart you are using displays depth in meters, feet, or fathoms (1 fathom=6 feet).

2. Graphing the Depth Profile

Draw a transect on the Lake Superior map from Duluth to Sault Saint Marie. There will need to be a turn in the transect because of the shape of Lake Superior. Have students determine the greatest depth along the transect. Also have students determine the length along the transect. Ask students to determine if the deepest point in the lake happens to be along the drawn transect.

Create a graph with length along the x-axis and depth along the y-axis. Depth should start just below the deepest point and decrease up the y-axis. To fit the large length across the lake, the graph paper should be cut into at least four thin pieces and taped together; for graph paper with 20 boxes per inch, it works well to cut the paper into 4 pieces, each of which is 50 boxes high and 200 boxes long. With 20 box/inch graph paper, each individual box can represent one kilometer for the length and 10 meters for the depth. If conversion is necessary, 1 meter = approximately 3 feet.

Note that in using meters for depth and kilometers for length, the units are obviously different, however it will still provide a striking image of comparing depth versus length.

3. Worksheet

Have students fill out the Depth Soundings worksheet. Together with the graph, this will allow you to assess your students' comprehension of the activity.

4. Conclusion

Ask students how their depth profile of Lake Superior compares with the depth profile on the provided chart. As a group, using the board, quickly create a cross section with depth and length at the same scale. This should show that even on the scale of a whole chalkboard the depth of the lake would hardly show.

ASSESSMENT

Discuss the "skinned knee" model of Lake Superior. Ask the students if they can figure out how Lake Superior could possibly be compared to a skinned knee!? The lake is like a skinned knee, it covers a lot of surface area, but is not very deep! It is also like a skinned knee in that the potential for airborne contamination (i.e. infection) is great! This discussion can serve to link this lesson with a study of airborne, nonpoint pollution types/sources.

EXTENSIONS

- Have students estimate how long their graph would be if they were to create a graph for all of the Great Lakes. Complete a depth profile for all of the Great Lakes and graph the lake elevation differences.
- Draw depth contour lines on a map of Lake Superior at intervals of 100 feet, 50 meters, or 20 fathoms and use different colors to represent each level of depth.
- Compare length to depth of the various Great Lakes using scale models. For example, draw a picture of an ore boat standing upright with one end on the bottom of the lake (the largest Lake Superior vessels are just over 1000 ft long! 1000 ft = 303 m).

Depth Soundings Worksheet

NAME_____ DATE_____

Analysis: Answer the following questions about your profile.

1. Look at your plots for the following questions:

What percentage of the cross-section is between 1 and 99 meters? _____

What percentage of the cross-section is between 100 and 199 meters? _____

What percentage of the cross-section is between 200 and 299 meters? _____

What percentage of the cross-section is between 300 and 399 meters? _____

What percentage of the cross-section is more than 399 meters ? _____

2. What appears to be the most common depth level? _____

3. The surface level used on maps of Lake Superior is generally 601 feet above sea level (about 183 meters). This means that the "0" level on your profile is equal to 601 feet above sea level.

What percentage of your profile shows the bottom of the lake being below sea level? _____

4. Are there any plot locations on your profile representing places in the lake where a 1,000 foot ship could stand on end and be below water level? _____

Which locations? _____

What is the approximate horizontal scale of your profile? _____

What is the approximate vertical scale of your profile? _____

5. Compare the two scales to each other.

6. If we were to change the horizontal scale to make it equal to the vertical scale, what would happen to the appearance of the profile?

a. The profile would appear the same.

b. The profile would appear to flatten out (stretch out).

c. The profile would appear steeper (squeezed together).

7. Record your thoughts about your profile and what it shows you. (2-3 sentences)

Taking it Personally

(ACTIVITY THREE OF THE "EXAMINING THE GREAT LAKES" UNIT)

Students create graphs of their choice using the Great Lakes Data Chart.

TOPIC
Assimilating activities two and three.

AUDIENCE
Grades 7 and up; 15-30 students

LENGTH
2 hours

GOAL
To choose data that is personally interesting and apply it, thereby focusing interest and expanding knowledge.

OBJECTIVES
- *Students will use a data table of great lakes information to compare the Great Lakes.*
- *Students will make and use charts to support or refute a claim.*

MATERIALS
- *Great Lakes Data Chart (from Appendix, one copy per student)*
- *"Taking it Personally" answer sheet (one per student)*
- *pencil*
- *atlas or maps*
- *graph paper*
- *encyclopedia*

BACKGROUND

Lake Superior has the deepest point of all the Great Lakes, this being 405 meters. Lake Erie only reaches a maximum depth of 64 meters. The average depth of Lake Erie is 19 meters, while the average depth of Lake Superior is 147 meters. All the others fall somewhere in between. For more information, see the introduction to *The Physical Lake Superior.*

GETTING READY

Prepare copies of the Great Lakes Data Chart and the "Taking it Personally" answer sheet (one of each per student).

PROCEDURE

1. Introduction

Explain to students that this will be their opportunity to pick data that they find interesting and apply it to a specific question. They can focus their interest and expand on what they already know.

2. Taking it personally

In completing the Taking it Personally Worksheet, have students use the Whaddya Know? surveys, the Great Lakes Data Chart and an atlas or maps on which to base their answers for questions #2, 4 and 5, and graph paper to create graphs for questions #3 and 5. Encourage honesty in the responses by explaining that the only correct answers to the questions are what they (the students) personally feel.

3. Students present their results

Have students present their graphs and explanations for number five to the class.

ASSESSMENT

Evaluate the graphs based on accuracy and support with detail. Check for comprehension by comparing it with the information on the data chart and seeing if they match.

EXTENSIONS

- Have students use a computer graphing program or a program that contains graphing capabilities to graph the information.
- Have students write an essay entitled "What makes a Great Lake?"
- Hold a scientific conference to determine which lakes of the world are "Great Lakes." Students can take on the roles of government representatives.

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Taking it Personally Worksheet

NAME_____ DATE_____

1. What information about the Great Lakes surprises you?

2. Use the average depth or the maximum depth information from the chart to create a graph. The graph can be either a bar, line or circle graph. Complete it on graph paper or use a computer graphing program if available.

3. Record your thoughts about what your graph shows (2-3 sentences).

4. Pick another set of data from the chart and create another graph. Record your thoughts about what this graph shows (2-3 sentences).

5. Pick another large lake of the world on which you can locate information. Compare that lake to the five "Great Lakes" and create at least two charts that support or refute the claim that your new lake deserves the title "A Great Lake of the World." Explain in writing how your charts support or refute this claim.
(The following are possible lakes to explore: Baikal, Caspian, Lake of the Woods, Great Salt Lake, Victoria, Winnipeg, Tanganyika, Great Bear, Great Slave, Aral, Malawi, Dead Sea, Vermillion, Mille Lacs or Crater Lake.)

Big Lake, Small Basin?

(ACTIVITY FOUR OF THE "EXAMINING THE GREAT LAKES" UNIT)

Students will first estimate and then determine the size of the Lake Superior drainage basin and how it compares with the rest of the Great Lakes.

TOPIC
Drainage areas of Lake Superior and the Great Lakes

AUDIENCE
Grades 7 and up, 15-30 students

LENGTH
50 minutes

GOAL
To understand how greatly the surrounding landscape directly affects the waters of Lake Superior and the Great Lakes.

OBJECTIVES
- *Students will use a data table of great lakes information to compare the Great Lakes*
- *Students will solve mathematical problems*

MATERIALS
- *Great Lakes Basin Map (See Appendix)*
- *Big Lake, Small Basin worksheet (one per student)*
- *pencil and colored pencils*
- *Great Lakes Data Chart (in Appendix)*
- *calculator*

BACKGROUND

A lake basin is the area of land that drains into a lake. All of the precipitation that falls into this basin will eventually evaporate or collect in the lake. Lakes often become polluted not because waste falls directly into the lake, but because it is dumped inside the drainage basin, and it works its way into the lake. The danger in this is that sometimes people don't realize that when they dump something in their yard, it could end up in Lake Superior, their freshwater source.

GETTING READY

Prepare copies of Big Lake, Big Basin? worksheet. On one side, have the questions listed. On the other, have the Great Lakes basin map from the Appendix.

PROCEDURE

1. Introduction

Review with students the concept of "watershed." Every lake and river has a watershed. For some lakes, the watershed is much bigger than the lake itself. Is this true for Lake Superior or the other Great Lakes as well?

2. Worksheets

Have students follow directions and answer the questions on the Big Lake, Big Basin? worksheet, which includes the following:

- Color each of the five Great Lake basins a different color.
- Locate where students live on the map and mark this location with a star.
- Answer questions about the basins.

3. Discussion

Have each student give a brief summary of their findings. Was anyone surprised by the results?

What are the implications of Lake Superior's small watershed area in comparison to its surface area? Explain to students that even though Lake Superior itself makes up about 40% of the watershed, over 60% of the water entering Lake Superior comes directly into the lake, since the lake generates its own rain.

ASSESSMENT

- Observe students' responses to questions during a class discussion.
- Check and correct the answers that they filled in on the worksheet.

EXTENSIONS

- Try the activity, "A Raindrop Journey," for fun and to illustrate the role of the land part of the watershed in keeping the lake clean.
- Compare the populations in each basin and the type and effect of pollution.

Big Lake, Big Basin? Worksheet

NAME_____ DATE_____

1. On the reverse side of this page, color each of the five Great Lake basins a different color.

2. Locate where you live and mark the map with a small star at this location. If your city is not named, write the name on the map. If you live outside of the map area, draw an arrow in the direction toward where you live and the estimated distance to the closest Great Lake.

3. Do you live within one of the Great Lake basins?_____ If yes, which one?_____

4. Using the Great Lakes data chart, compare the surface area to the drainage area for each lake. Estimate the percentage of each basin that is occupied by the lake itself.

SUPERIOR = _____ MICHIGAN = _____ HURON = _____ ERIE = _____ ONTARIO = _____

5. Estimate the percentage of each lake basin in relation to the total Great Lakes basin area.

SUPERIOR = _____ MICHIGAN = _____ HURON = _____ ERIE = _____ ONTARIO = _____

6. Use the information on your Great Lakes Data Chart to calculate the following:
A) The percentage of each lake basin that is taken up the the lake itself (surface area / drainage area x 100 = % of basin that is the lake)

SUPERIOR = _____ MICHIGAN = _____ HURON = _____ ERIE = _____ ONTARIO = _____

B) The percentage of the lake basin in relation to the total basin drainage area (lake drainage area / total drainage area x 100 = % of total great lakes basin)

SUPERIOR = _____ MICHIGAN = _____ HURON = _____ ERIE = _____ ONTARIO = _____

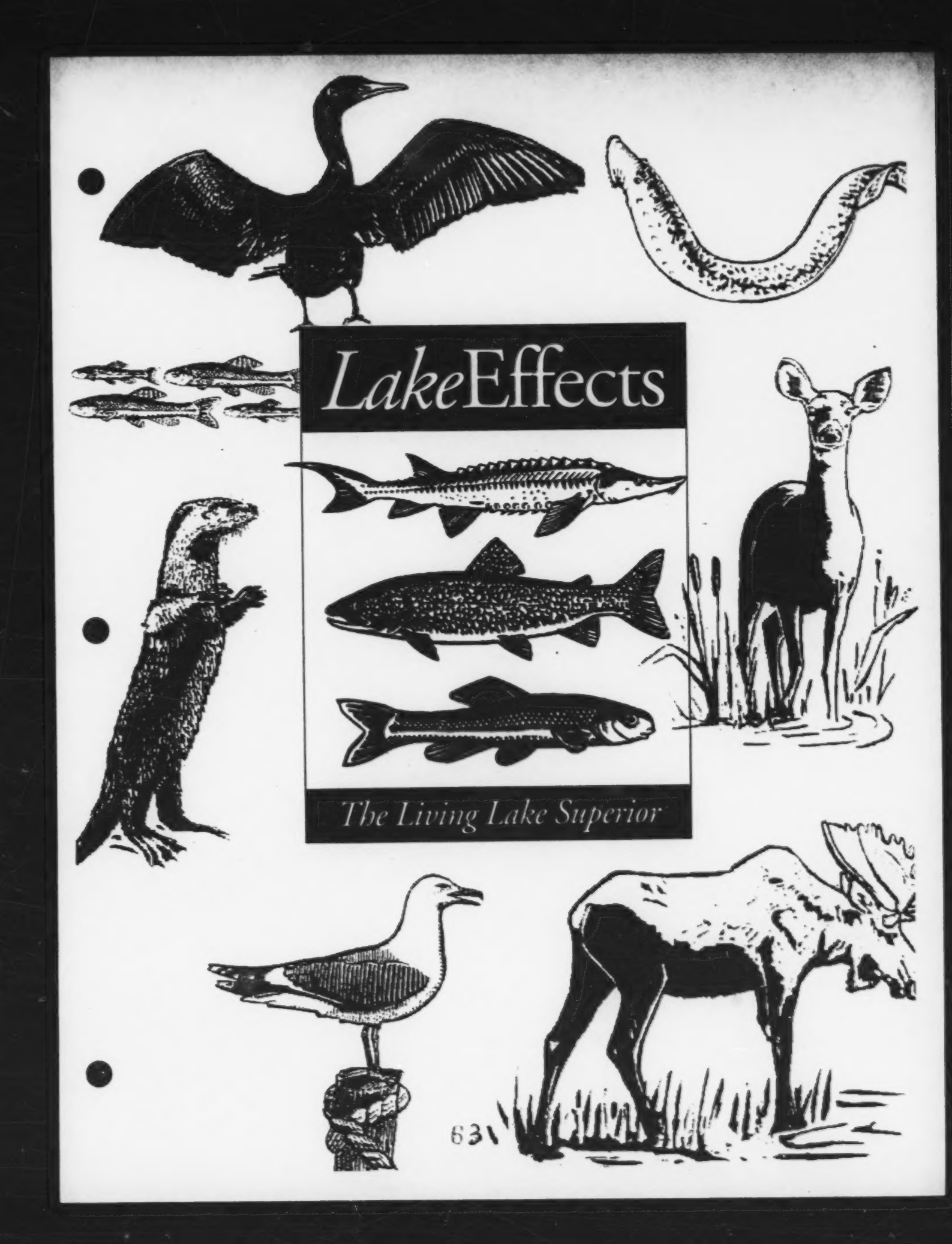
7. Compare the surface area of Lake Superior to the total surface area.

LAKE SUPERIOR = _____% OF THE TOTAL SURFACE AREA OF THE GREAT LAKES

8. Compare the volume of Lake Superior to the total volume of the Great Lakes.

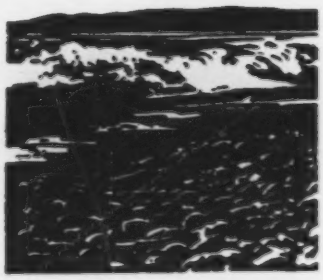
LAKE SUPERIOR = _____% OF THE TOTAL VOLUME OF THE GREAT LAKES

9. Record your thoughts about this information (2-3 sentences).


LakeEffects
The Living Lake Superior

The living lake...what does that make you think of? Lake trout? Common Loons? Hawks? Timber wolves? White pine? Or perhaps systems of plants, animals, and the "non-living" (abiotic) elements of the environment as well? Each autumn, more than 75,000 hawks in southern migration pass over Hawk Ridge in Duluth, Minnesota. En route south, the hawks take advantage of the warm air being pushed up the hillside by the cold lake breeze. By soaring on the lake effect wind currents, the hawks can avoid flying the long distance south and east across the lake. This is just one specific example of the unique nature of the living lake.

The living lake is all of these things and more...including the human dimension.



A COLD, QUIET PLACE

Despite its vast size, Lake Superior is not a rich habitat. Ecologists describe large parts of Lake Superior as "ultra-oligotrophic." In other words, if there was a scale of 1 to 10, where 1 was a lake that was choked with life ("eutrophic") and 10 was a lake that was very low on life ("oligotrophic"), the open parts of Lake Superior are like an "11."

Why is the open lake so sterile? Aquatic life depends mostly on temperature and nutrients. The open lake is low on both. The temperature averages around 40°F (4°C). And because of the lake's small watershed area and other factors, the amount of essential nutrients like nitrogen and phosphate entering the lake is also very low.

The result is a fairly simple food chain in the open Lake Superior. The clear, cold water supports very little phytoplankton, such as algae. These few phytoplankton feed even fewer zooplankton, such as the crustacean *Diporeia hoyi*. By the time the herring eat the water flea and the lake trout eat the herring, the open lake is pretty quiet.

NATIVE FISH OF LAKE SUPERIOR

Of course the living Lake Superior is far more than its open waters. Ask any angler where they catch fish out of Lake Superior and (if they're talking) they'll direct you towards a stream or shoal, where the fish gather out of the open lake to spawn or feed.

Lake Superior is host to approximately 48 species of native fish. The open water of the lake is dominated by species like the trouts and salmons, white fish, lake herring, burbot, sticklebacks, and sculpins, which can tolerate cold and nutrient poor environments. Nearshore waters also contain suckers, rainbow smelt, and members of the minnow family. Below is information about a few of the many fascinating Lake Superior fish species:

■ LAKE TROUT

The lake trout—*Salvelinus namaycush*—prefer cold water temperatures. In midsummer the lake trout live in the depths of the open water. Spawning occurs on rocky shoals from 1 to 30 meters deep, primarily in October to December. Lake trout "home" to their natal spawning grounds.

The lake trout is a predator fish, partially evidenced by their "torpedo" shape. Adults measure 24-40 inches (62-103 centimeters) in length and have light spots on a dark background with a light underside.

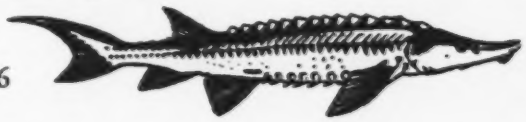
The siscowet, or "fat" trout, is a subspecies of the lake trout and usually stays in deeper water than the "lean" lake trout. A third subspecies is the "humper" which stays just offshore near shoals and reefs.

In the 1950s, the lake trout population suffered a severe decline because of sea lamprey predation and uncontrolled commercial fishing. Stocking programs, sea lamprey control programs, and harvest restrictions have restored lake trout to about 33% of historic levels. Natural reproduction by lake trout is increasing in many parts of the lake. Although sea lamprey have been reduced to about 10% of their pre-control level, lamprey-induced mortality still equals the combined catch by sport and commercial fisheries.

■ *LAKE STURGEON*

The lake sturgeon—*Acipenser fulvescens*—is a large fish that spawns in streams in the spring. Its habitat is the bottom of the lake in relatively shallow areas such as Keweenaw Bay, St. Louis Bay, near the Apostle Islands, and several points along the Canadian shore. Sturgeons use whisker-like barbels to feel for fish, crayfish, mollusks, aquatic insect larvae, and aquatic vegetation.

When commercial fishing began, the large sturgeon, which can reach lengths of 3-6 feet (1-2 meters), was originally discarded and even purposely destroyed as it was seen as a nuisance by netters. Later, in the late 1800s, lake sturgeon were exploited for their eggs, and for the gelatin from the lining of the gas bladder which was used in making isinglass windows. This was an extremely difficult time for the sturgeon, as the female is only capable of reproducing after it reaches 24 years of age. After the initial spawning, it only reproduces once every 4-6 years.



With stream spawning habitats being destroyed by lumber mill wastes and the construction of dams, the sturgeon were unable to rebound naturally. In 1921 the lake sturgeon became protected and now are illegal to catch in Minnesota waters. Fisheries management agencies in Minnesota and Wisconsin, and the Great Lakes Indian Fish and Wildlife Commission are involved in intensive stocking of streams in the hopes that the lake sturgeon populations will recover. The operation of dams on some rivers are also being regulated to promote fish survival.

■ *WHITEFISH*

The lake whitefish—*oregonus clupeaformis*—spends the entire year in near shore habitat. In November and December they spawn on reefs and shoals and in the summer move back to deeper, inshore water, a range of about 25 miles (40 kilometers).

A bottom-feeder, with an over-hanging snout, the whitefish does not eat other fish, but rather plankton and small invertebrate animals at the bottom of the lake. The whitefish's bottom-feeding

habits and small mouth save it from being taken by hook and line. Instead, the whitefish is a commercial catch, often considered the most delicious of all freshwater fishes.

The whitefish gets its name from being completely white; even its flesh is white. Its length ranges 17-27 inches (44-69 centimeters) as an adult.

Population declines in the late 1800s and early 1900s were primarily due to overfishing. The whitefish suffered further setbacks from parasitic lamprey attacks.

■ HERRING

The lake herring—*Coregonus artedii*—also called "cisco," are in the whitefish genus, and are unrelated to true herring which normally live in the ocean for a portion of their lives. Lake herring are named for their superficial resemblance to true herring. Lake herring are found lakewide, from the surface to 50 meters deep depending on season and temperature. Reefs are spawning territory in November and December for dense schools of lake herring. Young lake herring feed on zooplankton and adults feed on plankton, crustaceans, insects, and eggs. In turn, lake herring are food for larger fish like lake trout. Lake herring were historically the primary prey of lake trout, and are still considered to be the best food for lake trout because of their lakewide distribution and cold water adaptation.

Lake herring in Lake Superior historically yielded larger commercial harvests than all other species combined. Peak catches in the United States of 8.6 million kilograms in 1941 declined to only 100,000 kilograms between 1981 and 1983. This decline is attributed primarily to overfishing, although competition with rainbow smelt is sometimes speculated. Various regulations including harvest restrictions, depth restrictions, mesh restrictions, closed spawning season, and limited entry have been imposed by management agencies around the lake in an attempt to restore the stocks. Lake herring populations have shown some increase in most parts of the lake since the late 1980s.

LAKE SUPERIOR EXOTICS

The term "exotic" refers to any species that is not native to a particular area, and carries no automatic implications regarding harm or benefit. Many exotic bacteria, fish, mollusk, and plant species have been introduced to the Lake Superior basin. Some introductions were intentional, some inadvertent. These species arrive through fishery introductions, accidental dumping by sport anglers, contaminated boats moving between lakes, and migration through human-made canals. These exotic species have often had serious impact on the native species of Lake Superior and its watershed. The most notable exotic introductions are listed below.

■ THE SALMONID FAMILY

One large grouping of exotics are members of the trout and salmon family. Although there are many members of this family native to Lake Superior, such as the whitefish, lake trout, brook trout, and lake herring, there are many others that have been introduced.

Salmonids introduced into Lake Superior include the following species: brown trout from Europe, Atlantic salmon from the East Coast and rainbow trout, coho salmon, chinook salmon, and pink salmon from the West Coast. Some of these species have been very successful in Lake Superior, such as the rainbow trout (also called the "steelhead"); rainbow trout have done well in part due to their adaptability, along with the ability of rainbow trout to spawn 3-4 times during their lifetime.

Coho salmon are now mostly self-sustaining, and chinook salmon have significant natural reproduction. Brown trout and pink salmon are self-sustaining at low levels. Atlantic salmon stocking was discontinued in Minnesota waters after 1992 due to their poor survival and low return to the angler. They have not become established in the lake.

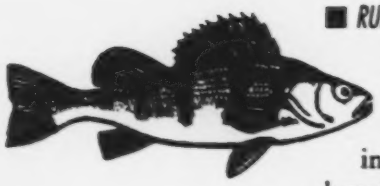
Atlantic salmon, "steelhead" rainbow trout, coho salmon, chinook salmon, and pink salmon in Lake Superior are landlocked forms of species that originally lived most of their lives in the ocean. These species naturally migrate up streams to spawn, and their young live in the streams until they undergo a dramatic physiological change called "smoltification." These smolts are silver in color, are tolerant of salt water, and have the urge to swim downstream. Because of this lifestyle, these are said to be "anadromous." The landlocked descendants of these species use Lake Superior as their ocean and spawn in tributary streams. Atlantic salmon were native to Lake Ontario because of its ocean connection through the St. Lawrence Seaway.

Many people view the introduction of members of the trout and salmon family as overwhelmingly positive. Sport fishing and a diverse fishery are often cited as examples of the benefits.

■ *SEA LAMPREY—PETROMYZON MARINUS*

The sea lamprey have greatly affected lake trout, burbot, and rainbow trout populations since the 1930s when they reached Lake Superior via shipping channels. The sea lamprey is a parasitic, eel-like fish with horny teeth around a rasping tongue. Lamprey spend the first 4-7 years of their lives in the gravel bottom of streams, living as a filter feeder. Then, as adults, they spend less than two years in the open lake. The adult lamprey fastens onto its prey, rasping a hole with its rough tongue. An anticoagulant in the lamprey's saliva keeps the wound open for several hours or weeks, until the lamprey is satiated or its victim dies. The adult lamprey reaches about 18 inches (46.2 centimeters) in length and each will kill about 40 pounds (18.14 kilograms) of fish in its 12-20 months as a parasite. That's one fish per lamprey for every fish caught by recreational or commercial anglers!

There are about 350,000 sea lamprey in the Great Lakes. Traps and chemicals used in streams reduce, but do not eliminate, the spreading lamprey population. Present levels are estimated at 10% of the pre-control levels.



■ *RUFFE—GYMNOCEPHALUS CERNUUS*

Ruffe (pronounced "rough") probably arrived in Lake Superior in the ballast water from incoming ships. It was first collected in 1986 in the St. Louis River. It is a small European fish from the perch family that competes with the young of walleye, perch, and whitefish. One of the reasons the ruffe out competes other fish in the St. Louis River is because it matures rapidly, reproducing at one year. Potential predators appear to find the ruffe undesirable as food. Initially, only black bullhead and large yellow perch preyed on ruffe to any extent. Recently, however, walleye and northern pike began including ruffe in their diet.

Because the ruffe may not survive in cold, midlake water, ships are encouraged to exchange ballast water in Lake Superior's open water to prevent the ruffe from spreading to other harbors and watersheds. Since its introduction, ruffe have spread along the south shore of Lake Superior to the mouth of the Amnicon, Brule, and Iron Rivers, and north to Thunder Bay. Their spread to Lake Huron was confirmed in the summer of 1995.

■ *RAINBOW SMELT—OSMERUS MORDAX*

Rainbow smelt apparently escaped into Lake Superior in the early 1930s from Crystal Lake, Michigan, where it was intentionally stocked. Rainbow smelt reached commercially harvestable levels in 1952. The harvest peaked in the 1970s and then declined sharply.

When smelt population was high, it became a primary prey for lake trout, chinook salmon, and other trout and salmon species. The nearshore habitat favored by smelt make it a less adequate food source for lake trout than the widely distributed lake herring had been.

The primary diet of the smelt includes crustaceans, invertebrates, and some small fish. This species is highly cannibalistic, consuming its own young as much or more than it consumes other species. As smelt populations dip to low levels and lake herring populations are rising, predator species appear to be slowly switching back to the native food source.

■ *ROUND GOBY—EOGOBIUS MELANOSTOMUS*

This bottom-dwelling fish was introduced into the eastern Great Lakes from ballast water. Like the ruffe, it is a native of eastern Europe. The goby can grow to a length of 12 inches. Goby have raised, "frog-like" eyes and a well developed lateral line (a canal of pores along the fish's body that contain sense organs), which allow for feeding in total darkness.

Round goby are aggressive fish, spawning several times a year and competing with native species such as sculpins and log perch. They were discovered in Lake Superior in July 1995.

■ *SPINY WATER FLEA (B.C.)—BYTHOTREPHES CEDERSTROEMI*

A zooplankton about 3/8 inch (1 centimeter) in length with a long tail spine, B.C. is native to Asia but has spread throughout northern Europe and Great Britain. Like the zebra mussel and ruffe, it was introduced accidentally and was first discovered in Lake Huron in 1984. Since then B.C. has not established itself in Lake Supe-

rior at the higher levels observed in the warmer Great Lakes.

B.C. feeds on smaller zooplankton that are important food for young fish. Very young fish are unable to eat B.C. because of its large spine, but once fish reach about 3 inches (75 millimeters) B.C. are consumed. The value of B.C. as a food source has been questioned because of the large amount of undigestible material.

■ *ZEBRA MUSSEL—DREISSENA POLYMORPHA*

Zebra mussels were first discovered in Lake Superior in 1988. They are a small European mollusk, no larger than two inches in size, with striped shells. The zebra mussel originated in Europe and the Caspian Sea.

Attaching themselves in great numbers to all solid surfaces, zebra mussels sometimes block city water supplies and industrial water intake/discharge pipes which could cost industry and cities billions of dollars to clean up. The zebra mussel also attaches itself to native mussels which has severely reduced native mussel populations in other waters. Although the numbers of zebra mussel are still low in Lake Superior, the lower Great Lakes have already experienced problems with the invading mollusk. The low temperature and low calcium content of Lake Superior water appears to hinder the spread of zebra mussels in the open lake.

The zebra mussel reproduces rapidly, producing as many as 30,000 eggs in one year. To prevent their spread, it is very important to empty bait buckets, livewells, and bilges on land before leaving the lake or river access. Zebra mussel larvae are microscopic and can be inadvertently transported in small puddles of water.

POLLUTION PATHWAYS

The pathways of pollution are diverse, wide-spread, and unfortunately, very much a part of the life of the lake. In some areas, cities directly discharge wastewater into tributaries of Lake Superior either through industrial discharge pipes or municipal sewers. This form of pollution is referred to as "point source" pollution because the source can be directly targeted and treated.

Because the lake has such a large surface area it is susceptible to pollution from thousands of miles away carried by wind and precipitation. Studies by the International Joint Commission show that over 90% of toxic chemical loadings in Lake Superior can be attributed to atmospheric deposition. Because this pollution is potentially carried many thousands of miles, its source may be difficult to trace. This is called "nonpoint source" pollution.

WHERE DO THE TOXINS GO?

Many toxins enter the lake, disperse, then settle into the sediments at the bottom, and may eventually reenter the food chain after being stirred up by dredging, shipping, storms, and burrowing animals. At this point, they may be undetectable even with the most sensitive instruments. It is when phytoplankton begin feeding in the bottom sediments that the processes of

bioaccumulation and biomagnification really begin.

Toxins from agriculture, pesticides and manufacturing like PCBs and the now-banned DDT do not break down easily in the environment, and instead are stored in fatty tissues of animals. Therefore, with every meal a zooplankton makes of phytoplankton, the toxins accumulate. Through the process of bioaccum-ulation, levels of persistent organic chemicals in zooplankton can reach levels of 0.123 ppm (parts per million). This process occurs in all animal species in the lake, and has been shown to cause serious developmental problems.

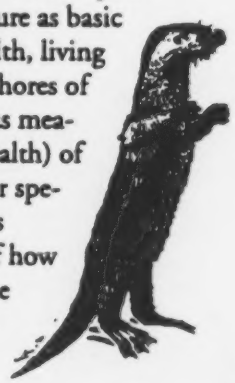
Each animal, however, does not exist in the lake independent of its predators and prey. Whatever one animal consumes can, and usually does, become a part of other animals after it has been consumed itself. The toxins consumed at one trophic level accumulate in the animals of the next trophic level as the smaller animals are consumed by the larger animals. It is through this process of biomagnification that salmon and trout, the top predators in the lake, become too toxic for anyone or anything to eat safely once they reach 30 inches (77 centimeters) in length.

Larger fish like lake trout feed on prey fish such as lake herring. A lake trout eats a little over 22 pounds (10 kilograms) of these smaller fish in eight years and up to 135 pounds (61 kilograms) in sixteen years; given that chinook salmon get bigger faster, in five years they consume as much as a 16-year-old lake trout! With each little fish consumed and each year lived, the amount of chemicals concentrates in the longer-living, larger, fattier fish reaching levels of 4.83 ppm. That's 25,000-6,000,000 times the water concentration! The eggs of birds that eat large fish have the highest concentration of chemical contaminants at 124 ppm because the yolk has a lot of fatty tissue. The large fish and the bird eggs are indicators of the condition of the lake as well as guides to what limits to place on human fish consumption.

Effects of bioaccumulation and biomagnification of toxins include crossed bills in birds and other deformities in fish, bird, and fish-eating animals. Low reproductive rates are also a problem. Though the toxins in Lake Superior's sediments are known to cause cancer, birth defects, and even neurological disorders, it is difficult to determine what the effects of eating contaminated fish are on humans because the time of exposure is usually long before the development of any problems. However, restrictions are usually placed on pre-teen children, pregnant women, and nursing women. (See Minnesota Fish Consumption Advisory in the *Appendix*).

INDICATOR SPECIES

Just as doctors use weight, blood pressure, and body temperature as basic indicators of human health, living things in and along the shores of Lake Superior can help us measure the condition (or health) of the lake system. Indicator species in the lake and on its shores provide a gauge of how healthy the lake is. Of the mammals, the otter and mink, which eat at the



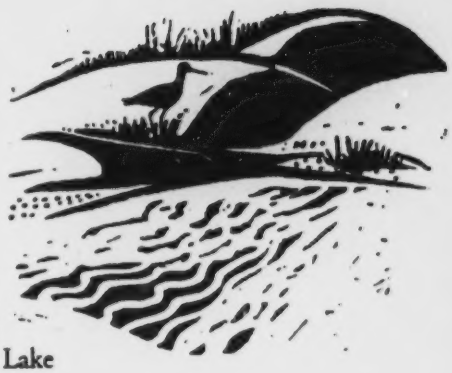
same level as humans on the food chain, are considered indicator species. Scientists study the reproductive development of these animals to determine the level or extent of contamination. Three birds, the double-breasted cormorant, bald eagle, and herring gull, are also indicator species. By studying birth rates and checking for defects like crossed bills, scientists can determine if toxins have concentrated to outstanding levels in the environment in which the birds live.

Herring gull eggs are commonly used for chemical analysis because toxic chemicals can be detected in them before they are detected in the open water. The egg yolk is rich in fatty material where toxins like PCBs accumulate.

Lake trout have been designated as a top aquatic predator of the cold-water community and the *Diporeia hoyi* (a crustacean) as a key organism in the aquatic food chain. Both of these species are studied as indicator species. All top predator fish species are indicators of environmental health, as evidenced by the *Minnesota Fish Consumption Advisory*, put out by the Health Department. The *Advisory* sets consumption advisories for numerous Lake Superior species including lake trout, chinook salmon, coho salmon, whitefish, rainbow trout, and brown trout.

The Anishinabe remind us that the health of our water is directly related to the quality of life for all living things on this planet. By studying these indicator species, scientists can determine how damaged the lake is and how the rest of the Lake Superior basin will be affected, especially through bioaccumulation and the flow of water. The scientific data can then help us to adjust our behavior to the benefit of the lake.

BIODIVERSITY



Biodiversity occurs, and is defined, at different levels—genetic, species, and ecosystem. Genetic diversity includes the variation in genes within and between populations of the same species. Diversity in species is the variety and abundance of species. Ecosystem diversity refers to variations that can be local (a wetland), regional (the Lake Superior basin) or global (the Earth). The Lake Superior watershed supports a wealth of biologic diversity, including species of global significance (e.g. Braun's holly fern and calypso orchid) and a great landscape variety (fen, coastal marsh, sand dune, rocky shoreline, forest, etc.). It is important to note that lake ecosystems are inherently diverse and always interconnected, comprised of not only the open water, but also the shoreline systems, and upper watershed systems as well. The Nature Conservancy has used the example of the hooded merganser to illustrate this point; the merganser is hatched in a tree cavity, then raised in sheltered shallows, and only emerges on the big lake water when it is old enough to begin feeding on open water organisms and fish.

The large size of Lake Superior, along with the topography, climate, soils, and position of watershed all contribute to the biodiversity of the Lake Superior system. The uniqueness of Lake Superior biodiversity is well illustrated by the occurrence of arctic plants along the Canadian north shore. These plants tend to live in small communities at the most marginal point in their range. The specialized soil, climatic conditions, and topographical features have created environments where disjunct populations can survive.

■ SUPERIOR FORESTS

The vegetation provides a colorful part of the life story of Lake Superior. Lake Superior creates a micro-climate around the lake which encourages the extension of diverse mixed forest habitats into the north and arctic habitats into the south. Along the northern shore in Ontario, some examples of arctic plants are present, found nowhere else at such a low latitude. The far northern shore in Ontario is a northern boreal forest of spruce, fir and jackpine. The southern shore is a mixed zone of sugar maple, basswood, aspen, and birch. Along sand beaches like Minnesota and Wisconsin Points and the Grand Sable Dunes, the flora is sand dune shrubs and plants found nowhere else in the Midwest, as well as protected or endangered birds like the common tern and the piping plover. The Lake Superior Highlands are a northern extension of the south shore forest, existing only as a narrow band from Duluth to Canada. This strip of forest can reach along the north shore because of the moderating effect of the lake on coastal weather patterns. All three of these forests once had great stands of white pine which were later decimated by fires and uncontrolled logging.

The living lake is a watershed of diversity and beauty. From the pre-Anishinabe residents of the watershed to the most recent human arrivals, people have had a dramatic impact on the life of the lake.

■ THE HUMAN ROLE

Lake Superior's history of human use shows a lack of the understanding of biological diversity. The first obvious sign of this lack of understanding occurred when Europeans came in search of fur-bearing mammals and depleted the numbers of these animals, some species nearly to extinction. The next human disregard for biodiversity was the pursuit of the rich virgin forest resources. In some areas the harvest of timber was so extensive that the natural forest composition was permanently altered. Farming was attempted on post logging cleared lands in the Lake Superior watershed, usually without success; the poor soils could not support agriculture after the clearing of the forest.

Commercial fishing, overharvesting, the introduction of certain exotic species and pollution have had a devastating impact on the native Lake Superior fishery. In the 1995 State of the Great Lakes Report, prepared by both Environment Canada and the US Environmental Protection Agency, it was noted that prior to 1950 the Canadian waters of Lake Superior's north shore supported 200 distinct stocks of Lake trout, including approximately 20 river spawning stocks. All of the river stocks are now extinct, along with many of the lake stocks. It is also interesting to note that in contrast with dramatic declines in native species populations and species numbers, that biodiversity in terms of new species introduced (accidently or intentionally) has increased.

Lakes are dynamic places; change is a part of an on-going process. Human involvement with the lake has intensified the process of change. Comparing Lake Superior today to the lake of 400 years ago, "The 1994 State of the Great Lakes" report finds our lake to be severely degraded in terms of both reduced biodiversity and the current existence of toxic substances and human pathogens. We must be mindful of this change.

72

Lake Superior Circle of Life

Experience the interconnections of a Lake Superior food web in this fun and engaging activity where students must cooperate in order to complete the web.

TOPIC
Interdependency of life.

AUDIENCE
Grades 2-6, 15 students per group maximum

LENGTH
25 minutes

GOAL
To gain insight into the interconnectednesss of nature.

OBJECTIVE
- Students will name two elements of the ecosystem to which their element connects.

MATERIALS
- cards with names of ecosystem members, i.e. algae, sun, minnow, etc. (optional)

BACKGROUND

The living Lake Superior is a complex set of interrelationships, with many different habitats and species. Yet in reality all these parts are tied together. Each part is essential to the whole. Though a cattail in a coastal marsh may just be a piece of a piece of a Lake Superior habitat, it is a vital part of the living lake. This activity demonstrates the idea of interconnectedness in the Lake Superior ecosystem.

GETTING READY

If desired, make up the cards with the names of the ecosystem parts. Putting them on a 3-foot string allows you to put them over students' heads.

PROCEDURE

1. Setting the stage

Break the students into two groups if necessary. Have them stand in a circle. Explain that each one of them is going to be a different member of the Lake Superior ecosystem. (Optional: hand each student a name card as you talk about their role.) Start by telling one that he or she is a lake trout. What does a lake trout eat? Minnows. The next person in line is a minnow. What do minnows eat? Water fleas. The next person in line is the flea. Water fleas eat algae. Algae get their energy from the sun. The next person is the sun. The sun allows a cattail plant to grow. The plant gives off oxygen for the fish to breathe. The oxygen is stored in the water and fish receive oxygen through their gills. Decomposers break the lake trout into soil when it dies. Trees grow from the soil. Eagles live in the trees. Eagles eat lake trout. The circle is complete.

So a sample circle order is:

Water fleas

Minnow **Algae**

Lake trout **Sun**

Eagle **Cattail**

Tree **Oxygen**

Soil **Decomposers**

Water

This could also be done by having the kids create their own character. They get to say what they are, as long as it somehow relates to the character that was presented before them.

2. Holding the circle together

GRADES 2-4

Ask students to stay in their circle and get on their knees, everyone facing inward. Ask students then to link arms and elbows with the person next to them. Remind students of their roles, then ask them all to slowly lean back on the count of three. Students will be holding each other up as they lean backwards. The circle should hold itself up, just as a healthy ecosystem maintains itself; point this out if it does work. Eventually the circle will break.

GRADES 4-6

These older children can try a "lap sit." Ask students to stand in a fairly tight circle. Each will turn to the right and face the back of the person in front of them. Their left feet should all be touching, heel to toe, forming a circle. They have to coordinate to sit down together on the knees of the person behind them. On a slow count of three, they will all slowly sit down, guiding the person in front of them onto their own lap.

3. Wrap-up

Both activities stress the interdependence of all the creatures living in or around the lake. Since the circle will have probably broken at some point, ask the students at the breaking point which part of the circle of life they represented. If you remove one part of the circle, the whole system may fail.

ASSESSMENT

Have each student name out loud or write on the back of their card the names of two ecosystem elements to which they are connected.

EXTENSIONS

- Using a ball of yarn, try to make more connections between members of the ecosystem. Have the students stretch their thinking skills. Whenever they discover a new relationship, pass the yarn between those two members until the circle is interconnected by a giant web. Use this to spark discussion.

7-1

Owl and Mouse

One student is a snowy owl, others are mice hiding from the owl...
In this exciting combination of "kick the can" and "hide and go seek," students play out the roles of both predator and prey, immersed in a natural setting.

TOPIC
Camouflage, animal habitat and predator-prey relationships.

AUDIENCE
grade 3-12, small or large group

LENGTH
20-30 minutes

GOAL
To experience the natural world from an animal's perspective.

OBJECTIVES
- *Students will be able to identify the snowy owl as a migrant that overwinters within the Lake Superior watershed.*
- *Students will learn, through direct experience, about the varieties of animal camouflage.*

SETTING
Outdoor environment of trees or brushy field for game playing.

BACKGROUND

Every spring and fall snowy owls migrate along Lake Superior's northern shore, while many spend the winter by the lake as well. Along the way they must feed on prey such as mice. Snowy owls are easily seen in the Duluth area; a good viewing site is at the Duluth/ Superior shipyards where grain is stored for transport. Grain spilled from elevators, railroad cars, and trucks attracts rodents, and the rodent population attracts the owls. Like most owls, snowy owls hunt by perching at a certain spot and swooping down on their prey.

PROCEDURE

1. Introduction

Explain to students that they will become animals that travel along the North Shore and that they will play a game that combines Hide-and-Seek with Kick The Can. The students will become deer mice, and their objective is to avoid being eaten by the snowy owl.

2. How to be an owl

Discuss with students that snowy owls nest in the tundra of northern Canada and Alaska and then migrate to the boreal forests, bogs, and open country of southern Canada for the winter. Some snowy owls spend the winter as far south as Minnesota. In Duluth/ Superior, human actions (grain shipping) provide Lake Superior residents with unique opportunities to view this interesting bird.

3. Round one

In this activity, "It" is the snowy owl. The owl finds a central location, closes his or her eyes and counts to fifteen. The mice run and hide. The mice can hide anywhere they can reach in the count to fifteen, but they have to be able to see the owl. Once the owl is finished counting, he or she will make some sort of motion with the arms. In order to win the game, the mice will have to be able to repeat this motion.

The owl must remain on its perch throughout the entire game; the owl can only move up and down on its perch (bending knees) or turn its head (remember, owls can turn their heads almost 360 degrees; students can simulate this by pivoting on the perch). The mice remain still while the owl tries to pick them out. When the owl sees a mouse, he or she should point to them, call them out by name and if necessary describe their hiding place (e.g. "I see Joe behind the pine tree"). When mice are caught, they come to the owl's perch, but cannot help the owl find other mice until the next round.

4. Round two

Once the owl has picked out (or "eaten") all the visible mice in the first round, both the owl and the caught mice close their eyes and count to ten. All the remaining mice must change locations, moving at least three steps closer to the owl. And the hiding mice must still be able to see the owl (since they would want to know if it is going to swoop down on them). The owl and the caught mice open their eyes and again try to pick out mice. The caught mice can help the owl, but the one owl must be able actually to see the mouse that is hiding.

If at this stage the owl has caught all the mice, then the owl "wins." If not all of the mice are caught, the owl calls out for the mice to try to tag the owl. The first mouse to tag the owl and repeat the correct arm motion wins and becomes the owl for the next round.

5. Wrap-up

After doing this activity a number of times (students will want to do it all day), discuss with the students what they learned about how animals might interact in this habitat. It is important to point out that although an owl's vision does assist the bird in hunting, owls depend greatly on their hearing and are able to pinpoint even faint sounds with outstanding accuracy. Ask about camouflage. Often the most successful "mouse" has a well-camouflaged outfit on. How else do mice hide from predators? Share with students the following interesting facts to generate interest in the unique natural history of the snowy owl:

- Other large birds, such as geese and eider nest near snowy owl nests for protection from Arctic fox.
- Snowy owl breeding is related to rodent (lemming) abundance in the arctic; the owls will forgo breeding when lemmings are scarce.
- Some years snowy owls "invade" the Duluth area, in 1991/92 autumn-spring 121 snowy owls were reported in the state of Minnesota; 33 snowy owls were banded in the Duluth area, and 12 individuals owls made it to southern Minnesota!
- Snowy owls prey upon small mammals such as rabbits, voles, and mice, as well as birds; they are not as dependent on mice/vole populations as some of the other owl species.

ASSESSMENT

Students will be able to identify the snowy owl as a part of the life of Lake Superior based on its migrations into the Lake Superior Watershed.

EXTENSIONS

Try this game with costumes. Have some students wear fluorescent hats or jackets; give others camouflage clothing; try handing out flippers, bicycle flags, or dark face masks. Play the game again and use the results to bring out a discussion of behavioral adaptations.

Getting Acquainted with Aliens

There are aliens living in our Lake! This comprehensive look at exotic species *presents an introduction to their effect on the ecosystem, their successful spread through Lake Superior and our attempt to control them. Students research exotics and present their findings in a "Symposium on Aliens."*

TOPIC
Exotic species of Lake Superior and the St. Louis River.

AUDIENCE
grade 7-10

LENGTH
Two 50-minute class periods plus one evening of work at home

GOAL
To understand how exotic species can disrupt native ecosystems, and how such disruptions can be minimized.

OBJECTIVES
- *Students will be able to name and describe major adaptations of six exotic species found in the St. Louis River and Lake Superior.*
- *Students will be able to explain the major causes and effects of exotic species introductions.*
- *Students will discuss the pros and cons of various techniques for controlling exotic species.*

MATERIALS
- *Exotic Species Chart — one copy per student (Chart included with this lesson)*
- *Exotic Species Chart — as transparency*
- *Exotic Species Notes (optional) — one copy per student*
- *Brochures and pamphlets containing information about places and resources in and around Lake Superior*
- *Computer Lab with Internet connections to Great Lakes Information Network (optional). GLIN can be accessed through a Gopher search or on the World-Wide Web at "www.great-lakes.net".*

BACKGROUND

Exotic species can be considered as "biological pollutants" in an ecosystem. Typically, "successful" or "pest" exotics disrupt food chains, decrease biodiversity, and may drastically alter entire ecosystems. Some scientists believe that they comprise a far more serious problem than chemical pollutants, because much attention has been given to the latter problem, but little to the former. Preventing the introduction of exotics is far easier than controlling them once they are here, so an understanding of methods of introduction, as well as characteristics of potentially "successful" exotics, is vital for all citizens. Exotics are in a sense "real aliens", and students are often quite interested in them. This lesson seeks to acquaint students with the causes, effects, and control measures for "invasions" of these "aliens".

The following exotic species make excellent subjects for study:

ZEBRA MUSSEL, SPINY WATERFLEA, RUFFE
LAMPREY, PURPLE LOOSESTRIFE
EURASIAN WATERMILFOIL, GOBY
RUSTY CRAYFISH, RAINBOW SMELT

Many of these exotic species first arrived in Lake Superior through ships that docked in the Duluth–Superior harbor. The harbor water is much warmer, shallower and more nutrient-rich than the open lake, somewhat similar to the harbors from which the ships came. The St. Louis River estuary is thus a "hotbed" of Lake Superior exotics.

GETTING READY

Collect pamphlets and brochures and/or familiarize yourself with the workings of the Internet and GLIN if students do their research in a computer lab.

PROCEDURE

PART A: DAY ONE— RESEARCH AND BACKGROUND

1. Introducing aliens

Depending on the ages of the students, ask for their definition of and examples of "aliens." You may want to discuss this to some extent— not only what they are, but also what they do, what the consequences of their being here are, what the usual response toward their "invasion" is. Then, using the definition they've given, tell the students that they will be studying REAL aliens to ecosystems, better known as exotic species. You may use the notes provided as a discussion guide or you may want to use Dr. Bill Swenson's video (see "Contacts") as a fairly scientific introduction to exotic species.

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2. Explain project

Explain the goals of the students' research: each student will become acquainted with one exotic species which has caused problems in the St. Louis River and/or Lake Superior. Each student is to become an "expert" on that species, and ultimately will be expected to teach the rest of the class about that species.

3. Dive in!

Distribute the assignments randomly. Students are to use the pamphlets and brochures, the Great Lakes Information Network or both to research their species, and write out at least notes which will answer these eight questions about their exotic species:

Name: Who am I?

Origin: How did I get here?

Food: What do I eat?

Food-getting: How do I obtain my food?

Trophic Level: At what level in the food chain do I feed? With whom do I compete?

Adaptations: What characteristics help me to survive?

Harmful Effects: What problems do I cause in my new ecosystem?

Control Measures: How might my harmful effects be limited? What can prevent me from spreading further?

If time allows, have the students begin to read their articles and write out answers to questions in class; the remainder of their work must be completed as homework.

PART B: DAY TWO— THE SYMPOSIUM IS CONVENED

1. Preparation

Students should first meet in "committees of experts"— that is, species groups— to share and check out the information they have uncovered. This is a time for each "expert" to gain confidence in his/her understanding of his/her own species before presenting it to the class.

2. Presentations

The presentation may be conducted as "The First Annual Symposium on Exotic Species" or Alien Invaders, if you wish. The "experts" may form a panel, each expert presenting a part of the story, or the class may interview the experts to uncover the information. Each student should take notes on his/her own chart as this discussion proceeds.

ASSESSMENT

The entire class (led by the teacher or a student chosen to be the moderator) should compare and contrast the various exotics in the following categories:

I. What are the most common ways in which these aliens "invade"?

II. What characteristics are shared by successful exotic species?

III. What is the most common effect of the "successful" invasion of an exotic?

IV. What actions can informed citizens take to help control exotic species?

EXTENSIONS

- Proceedings of the First (or more!) Annual Symposium on Exotic Species could be "published." Each student could write a "single species" article, or a summary article addressing one of the four summary questions above. The proceedings could be directed at a target audience of adults, contemporaries of the students, or perhaps elementary students.
- Interested students might make puppets of the exotic species (and perhaps the native species with which they interact) for use in the school or at the Lake Superior Center.
- Have small groups of students write a play designed to teach younger children what exotic species are, how they have become a problem for our area, and what each of us can do to help control them.
- Investigate the "other" exotics, i.e. intentional species introductions, such as brown trout, Atlantic salmon, rainbow trout, coho salmon, chinook salmon, or pink salmon.

REFERENCES

Excellent publications are available from the Minnesota and Wisconsin DNRs and Sea Grant offices. The *Minnesota Volunteer,* an outstanding publication of the Minnesota DNR, has excellent periodic updates on the status of invader species. Subscriptions are recommended for far more than just this lesson, and are available for the asking or, better yet, for a small donation.

CONTACTS

Minnesota and Wisconsin Sea Grant—Doug Johnson, Jeff Gunderson.

Brule River Fish Hatchery and lamprey barrier.

University of Wisconsin Lake Superior Research Institute—Dr. Mary Balcer or Dr. Bill Swenson (has an entire curriculum notebook and video for $20).

LEARNING KITS

Aquatic Exotics available from Minnesota Sea Grant office or Lake Superior Center.

Zebra Mussel created by Illinois/Indiana Sea Grant and available from Lake Superior Center.

Exotic Species of Lake Superior Worksheet

Name						
Picture						
Origin *How did they get here?*						
Food						
Feeding method						
Trophic level						
Adaptation *What helps me survive?*						
Harmful effects *(on other life)*						
Control measures						

From the LAKE SUPERIOR CENTER LEARNING KITS:
Lake Superior ECOSYSTEM Learning Kit—"Getting Acquainted with Aliens"

Mussel Mania

This activity demonstrates the effect of a nuisance (exotic or non-native) species on an aquatic ecosystem. Turn your students into native clams, nuisance zebra mussels, perch, walleye, or plankton movers and let them catch plankton, smother the clams and compete for food.

TOPIC
Exotic species.

AUDIENCE
Grades 5-12, 10-25 students

LENGTH
20-30 minutes

GOAL
To gain an understanding of how exotic species, zebra mussels in particular, disrupt an ecosystem. To learn about ways we can help slow the spread of exotic species and why it is important not to transport species to new areas.

OBJECTIVES
- *Students will be able to describe how carrying capacity can be affected by zebra mussels.*
- *Students will be able to identify effects of the zebra mussel on other aquatic organisms.*
- *Students will be able to give reasons why zebra mussels are a successful nuisance (exotic or non-native) species in some lakes and rivers but aren't very successful in Lake Superior.*

MATERIALS
- *tape*
- *chalk or string*
- *2 hula hoops*
- *several sheets of newspaper or scrap paper crumpled into at least 100 tight balls*

BACKGROUND

Note the section on zebra mussels included in *The Living Lake Superior* background information.

GETTING READY

Mark off a circle (20 feet in diameter) with tape, chalk, or string. This area represents a portion of a lake or stream system. In this circle, randomly place two hula hoops to represent the native clam's habitat (a soft lake bottom). The rest of the area is a hard bottom. Within each hula hoop, stick a small piece of masking tape.

PROCEDURE

1. Review concepts

Review the four components of habitat with the group-food, water, shelter, and space. A body of water has limits on how much of each of these it can provide. The number of animals and plants that can be supported by a habitat without causing harm is called "carrying capacity."

Carrying capacity can vary from season to season or year to year. It is also affected by other things like zebra mussels, weather, and nutrients. Everyone in the group will try to meet their needs while being a clam, perch, zebra mussel or walleye.

2. Clams in the mud

Have the group assemble in the circle and mill around. Tell them that they are baby clams trying to find a great place to live. They can't stand still because they are drifting in the current.

After a few moments, yell "Stop!" Anyone not standing in a hula hoop has to leave the circle. Explain that native clams live in muddy or sandy bottoms, which are ONLY represented by the hula hoops. If there is more than one person inside each hoop have them mill again, and stop. The person nearest the small piece of tape has found the very best spot and can sit down. Others must leave.

Have the two surviving baby native clams sit down. Over the course of many years they have grown into adult clams and can no longer drift. Emphasize that finding the right kind of bottom at just the right time is very important for the clams, and can limit their numbers.

3. Feeding time

Identify two youth as plankton movers. They are the currents moving the plankton into the area. They should sit facing away from the circle. They will toss plankton (paper balls) at random over their shoulders into the circle.

The clams must catch the plankton in the air to simulate feeding. Anything missed stays on the ground. (Clams don't have hands to pick things up!) Assign scavengers to pick up the plankton and return it to the movers. (Later in the game, they will also return plankton to the movers after retrieving it from the tagged perch.)

4. Perch Patrol

Select three youth to add to the circle as perch. Perch feed on plankton. They will move around the inside of the circle and also try to catch plankton in the air (this is not a competition with the clams). They can also feed from the bottom (pick up stray paper balls).

After a few minutes, select two youth to add to the circle as walleye. The walleye eat the perch. They can run around the outside of the circle, reaching in and trying to eat (tag) the perch. Tagged perch must leave the circle and give their plankton to the scavengers to return to the movers. As perch are eaten, add more. Try to maintain at least one perch in the circle at all times.

5. Mussel in

Stop the action and explain that zebra mussels compete with native clams for food, and with perch for space. Zebra mussels can't live in the soft bottom like the clams, but must live on hard surfaces (anywhere outside the hula hoops). The zebra mussels will feed the same way as the clams.

Begin to add zebra mussels. Explain that unlike the perch, zebra mussels have few predators that feed on them. This allows the mussels to expand to the limits of their food supply. As it gets crowded, tell the group that since mussels can stick to hard surfaces, they can sit or stand in the hoops as long as they are either touching each other or a clam. Continue until all the clams are smothered with mussels or until everyone has had a chance to get back into the game. At this time, stop the game and discuss what has happened to the animals.

A quick look:

a) Mill around circle as baby native clams.

b) Say "stop."

c) Those inside the hula hoops stay. If more than one person is in each, have them mill again.

d) When you say "stop," have the person nearest the piece of tape in each hoop sit down—the others must leave.

e) Place two plankton movers and have them begin tossing plankton.

f) Assign several scavengers to bring plankton to movers.

g) Select three perch and send them in to feed on plankton also.

h) Add two students as walleye—they can reach in from outside the circle to catch perch. Tagged perch leave, giving their food to the scavengers.

i) Add zebra mussels—to start they can live on the hard surfaces outside of the hula hoops.

j) Add more zebra mussels—when crowded they can move into hula hoop area but only by sticking to hard surfaces.

6. Discussion

Discussion questions might include:

- From the viewpoint of the fishes and clams, what happened as more mussels were added? Was the carrying capacity changed for those species?
- What happened to the native clams in the end? How do you think they fare in real life?
- This activity modeled an environment where zebra mussels did very well. Would they do well in Lake Superior? (See *The Living Lake Superior* background information on zebra mussels.)
- What kinds of problems do you think zebra mussels create for people? (See *The Living Lake Superior* background information on zebra mussels.)
- What are some ways we can help slow the spread of zebra mussels?

ASSESSMENT

- Ask students to describe carrying capacity, and to identify the effects of the zebra mussel on other aquatic organisms.
- Have them draw an food chain system before and after the introduction of zebra mussels. Ask students to describe why zebra mussels haven't been very successful in Lake Superior.

Adapted with permission from Fishing...Get in the Habitat, copyright 1991 MinnAqua Program and Queen's Printer for Ontario, Youth Fisheries Education Program, copyright 1991.

TOPIC
Resources and locations within the Lake Superior watershed; biotic and abiotic components of the ecosystem; human interactions with the ecosystem.

AUDIENCE
Grades 4-12, 20-30 students

LENGTH
50 minutes if information is provided; 2-3 class periods if students are to do their own research

GOAL
To locate and state the importance of major biotic and abiotic resources found in the Lake Superior watershed, as well as the cities and parks which have been developed around them.

OBJECTIVES
- *Students will recognize the variety of resources found in and around Lake Superior.*
- *Students will identify numerous factors that define the special places of Lake Superior.*
- *Students will present researched information about specific locations in the Lake Superior watershed.*

Getting to Know the Watershed

What are the biotic and abiotic components of the Lake Superior Watershed Ecosystem, and how do we humans interact with and depend on them? Students research sites throughout the watershed, locate them on a giant floor map of Lake Superior, and then present their findings to the class.

GETTING READY

If you don't already have a giant Lake Superior map, make one yourself or, better yet, have a small group of students make a map (see *Appendix* for instructions).

Collect pamphlets and brochures from the following types of organizations:

Departments or Ministries of Natural Resources (flora and fauna, fisheries, state parks); tourist information bureaus of Duluth, Thunder Bay, Nipigon, Houghton, Sault St. Marie, Michigan and Ontario, Grand Marais, etc.—(mine sites, recreational activities, cities, parks, marinas, historical sites or museums, the Soo Locks); businesses and Industries (paper making, forestry, mining, municipal water treatment); Coast Guards (boating, shipping); port authorities; marine museums; national, state and provincial parks (Isle Royale, Apostle Islands, Pukaskwa Wilderness Park, Lake Superior Provincial Park); Hawk Ridge Nature Reserve (Duluth Audubon Society) and Whitefish Point Observatory; Sea Grant agencies. Group them into folders or large envelopes according to topic or location.

This lesson includes the leson "More Than Just a Lake!" from *The Physical Lake Superior*, page 26, so prepare that lesson as well.

Familiarize yourself with the workings of the Internet and GLIN, if you will have students do their research in a computer lab. Ideally, you will have one "resource file" per student, or per pair of students if students will be working in pairs.

Devise a list of possible locations for research. The list should be at least as long as the number of students in the class. Read the information below for background and suggested locations. Write the name of each site on a piece of paper and place all slips of paper in a hat so that students may select a site at random.

PROCEDURE

PART A: INTRODUCTION

1. Ecological concepts

Introduce or review concepts of "Ecosystem" as a group of living things interacting with each other and their environment, and "Watershed" as all the land which drains into a certain body of water. Ask students to identify several different ecosystems of which they are a part, and several different watersheds of which they are a part. Be sure students understand that small watersheds exist within larger watersheds, and small ecosystems within larger ones.

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2. The Lake Superior Watershed Ecosystem

Do the lesson "More Than Just a Lake!" in *The Physical Lake Superior* (do the version for older students).

3. Whaddya know?

How much do the students know about what is found within the boundaries of this watershed ecosystem? With the Lake Superior watershed overhead transparency to stimulate thinking, brainstorm with the students the places they've been or know about, and write them on the map. Then discuss briefly why each site has been developed— what biotic and abiotic components of the ecosystem led to the establishment of each particular site? Then point to and ask about certain other sites along or within the lake which have not been mentioned. Explain that each site holds clues which reveal how we humans depend on and in turn affect our environment. Because we depend on the resources of the watershed, we have the responsibility to understand these interactions and make environmentally sound decisions.

PART B: STUDENT RESEARCH

1. Explain goals

Explain the goals of the students' research: 1) that we understand the geologic and human history which has shaped our watershed, and 2) that we identify the biotic and abiotic factors in our watershed upon which we depend.

2. Make assignments

Distribute the assignments; have each student draw the name of a site or topic to be researched from the hat. Students are to use the pamphlets, brochures and/or the Great Lakes Information Network to research their sites, to explore the geologic and human history of their sites and to identify biotic and abiotic factors which have influenced the development of that site.

Students should be given paper (of the appropriate color if color keying is used) and asked to produce a legend— including title and a few brief paragraphs— which summarizes their research and can be displayed on the floor (wall) map.

PART C: STUDENT PRESENTATIONS

1. Individual presentations

Students should gather around the map, each as near as possible to the site he or she has researched. Each in turn should summarize for the class his/her findings about geology, human history, and local biotic or abiotic factors, and then place his/her "legend" on the map in its appropriate place. Each student may label and take notes on his/her own map as this discussion proceeds.

2. Review

As a class, recall the sites which have been presented, but in the following categories:

- How do we depend upon the watershed ecosystem?
  - biotic parts? (formerly white pine, now aspen; lake trout; berries; syrup)
  - abiotic parts? ("head of the lakes" water for transportation, drinking, industry; formerly iron now taconite; formerly copper, now snow)

MATERIALS

- *materials from the lesson "More Than Just a Lake!" (page 26)*
- *overhead transparency of Lake Superior watershed, from Appendix*
- *brochures containing information about places and resources in and around Lake Superior (see "Getting Ready")*
- *computer lab with Internet Connections to GLIN (Great Lakes Information Network)*
- *giant floor (and later wall) map of Lake Superior (see Appendix)*
- *printer paper—brightly colored works wells, with colors keying the type of resource. One possible scheme: GREEN = biotic resources; BLUE = abiotic resources including rivers and streams; ORANGE = cities and other human-made structures; PINK = parks.*
- *fine- or medium-point markers— one per student*

- How do we affect the watershed ecosystem? (diversion at Long Lake/ Ogoki, locks at Sault Ste. Marie, pollution/area of concerns at St. Louis and Nipigon Rivers)
- What are our responsibilities toward the watershed ecosystem, and how can we fulfill them?

The map, with the added legends should be mounted on the wall and used for reference during any subsequent study of ecology and the Lake Superior watershed.

ASSESSMENT

Have students, working in pairs, draw large "Watershed Webs" showing the interactions which take place between humans and the Lake Superior watershed ecosystem.

EXTENSIONS

- In lieu of student research time, the accompanying summary information can be printed on colored papers and included with the brochures and pamphlets. Students may then be given time to read and study the information and to summarize it for classmates as above.
- Have each student write a poem or children's story which illustrates at least three of the interactions they've discussed.

DULUTH, MINNESOTA

One of three "big cities" on Lake Superior, Duluth consumes 400,000 gallons of water from Lake Superior each day. Much of that taken in is returned to the Lake, but the question, of course, is: In what condition? The Western Lake Superior Sanitary District is a relatively modern and effective sewage treatment facility, but during storms, its capacity is overwhelmed, and Duluth dumps raw sewage into the St. Louis River just upstream from where it empties into Lake Superior.

Ten thousand years ago, most of what is now Duluth was under water— under Glacial Lake Duluth. The old shoreline is still clearly visible as Skyline Parkway, and the red clay sediments form a tough soil for gardeners in yards throughout the town.

The "Twin Ports" of Superior, Wisconsin and Duluth, Minnesota are among the busiest inland ports in the country. In 1995, 93 ocean-going vessels, 776 U.S. flag vessels and 269 vessels visited the port of Duluth. What is shipped?

– IRON ORE from the Mesabi Range is shipped to steel mills on the lower Great Lakes. 7 taconite (pelletized iron ore) plants have a production capacity of 55 million tons annually. Regional employment has been highly dependent on this mining industry:

16,450 employees in 1979
3,100 in 1986
5,352 in 1993

– LOW-SULFUR WESTERN COAL is shipped to Detroit, Michigan, where it is burned to generate electricity.

– GRAIN and SUNFLOWER SEEDS are shipped to foreign countries.

THUNDER BAY, ONTARIO

One of only three large metropolitan areas on the lake, Thunder Bay is a fitting "sister city" to Duluth, and the fact that these are two of the "big" cities on the lake illustrates the relatively undeveloped nature of the Lake Superior watershed. The Lake Superior basin's population averages 14 people per square mile (5 people per square kilometer), less than 10 percent of the Great Lakes average of 183 (68 per square kilometer) and far below Lake Erie's 567 people per square mile (210 per square kilometer).

Thunder Bay occupies one end of the mid-continent rift, which extended from near Thunder Bay to Kansas 1.2 billion years ago. Lava flowed from the rift for 100 million years, resulting in a layer of basalt as deep as five miles thick. The famous "Duluth gabbro" which forms the hills of Duluth is a part of this massive volcanic activity. Billions of tons of molten rock, moving from underground to the surface, caused the surface to gradually sink and formed the broad, shallow

Superior basin. Had the rift continued to evolve, the North American continent would have split in two, and Duluth and Thunder Bay might now be on an ocean instead of a lake.

GRAND MARAIS, MINNESOTA

Grand Marais began as a logging community. 90% of the Lake Superior watershed is forested. Northern boreal forest above Lake Superior, as in the Grand Marais vicinity, gives way in the south to a mixed forest zone for much of the basin. Spruce, fir and jack pine in the boreal forest are replaced by sugar maple, basswood, and birch in the mixed zone; grand white pines were originally scattered throughout both. At one time, Wisconsin, Michigan and Minnesota provided a third of the nation's forest products. Logging peaked in 1899. By 1939, the north central states supplied only 3%, largely due to the depletion of white pine. The industry, however, continues today— now mostly as pulpwood rather than saw timber. Wisconsin, Michigan, and Minnesota still directly employ 170,000 persons in the wood products industries.

Grand Marais today relies more on tourism than on logging; in fact, Cook County has the most tourism-dependent economy in Minnesota. In the three north shore counties (St. Louis, Lake, and Cook), tourists spent U.S. $436.9 million in 1991, creating an estimated 9,146 jobs. Tourism is regionally important; in 1992, tourists spent U.S. $63 million in Duluth.

HOUGHTON AND HANCOCK, MICHIGAN

Hancock and its sister city Houghton form the nucleus of Copper Country. The copper of the Keweenaw Peninsula was known to and worked by Native Americans long before Europeans learned to use it. But Europeans established smelters in the region in 1860, and dredged a 14 mile/22 kilometer channel for large ships to Portage Lake copper mining district in 1861. The "Ontonagon Boulder"— a 2 ton rock containing a single mass of pure copper— was delivered to Washington in 1842, making Michigan's Copper Country Famous. Today, however, copper reserves are depleted, and a depressed economy partially buoyed by tourism prevails.

ONTONAGON, MICHIGAN

The Gogebic Iron Range was discovered in 1883; Ontonagon sits lakeward of this range. The Range has been depleted, however, and today tourism, cabins and lake homes dominate the economy in this region. Northwest winds over Lake Superior in winter bring the "U.P.," or Upper Peninsula of Michigan, a great deal of "lake effect" snow—an average of 170 inches in parts of the Upper Peninsula, compared to approximately 77 inches in Duluth. The snowfall, combined with rough topography and a forested "wilderness," make winter sports popular in the region.

CLOQUET, MINNESOTA

The town of Cloquet grew up around lumbering and paper industries. Potlatch Corporation is a paper mill which in 1992 received a permit to expand its landfill as part of a $500 million mill expansion. Prior to the permitting process, 186 tons of contaminated waste per year was discovered to be leaking out of the landfill and into the St. Louis River; the waste includes lime sludge from the pulpmaking process, wood chips and bark, and contaminated ash, and has been found to include small amounts of dioxin and heavy metals. An additional 112 tons of soil material also is eroding into the river each year at the site.

BAD RIVER, WISCONSIN

Bad River, Wisconsin and Pays Plat, Ontario Native Communities are both current settlements, but descend from cultures dating back to between 7000 and 5000 B.C.—long before Europeans arrived. Evidence of a Copper Culture of Paleo Indians remains on Isle Royale and the Keweenaw Peninsula. Metal spear points and knives, stone tools and weapons suggest a semi-nomadic hunting and gathering culture which continued until 1000 B.C.

From that time until 1600 A.D., Woodland Cultures—including the Anishinabe ("real or genuine people") or Ojibway—established the first permanent settlements based on pottery and wild rice harvests.

During the "Golden Age of the Ojibway" between 1679 and 1736, two branches of the culture were centered in LaPointe, on Madeline Island in the Apostle Islands, and around the Pigeon River. During this time, the Ojibway served as "middle men" between French fur traders and the Dakota. Between 1836 and 1866, the Treaties of Land Cession led most Native American Tribes to reservations such as those at Bad River and Pays Plat.

SAULT STE. MARIE, MICHIGAN AND SAULT STE. MARIE, ONTARIO

The Soo Locks, completed in 1855, connect Lake Superior to the Atlantic Ocean by the St. Lawrence Seaway— a distance of 2,343 miles. The U.S. Hydroelectric Power Plant north of the locks generates over 150 million kilowatt hours of electrical power per year. First priority for use of this power is operating machinery at the Soo Locks. The remainder is used for homes and businesses in Sault Ste. Marie.

ST. LOUIS RIVER

The St. Louis River is the largest U.S. tributary of Lake Superior. Each year, 2.5 feet of water fall on Lake Superior as rain or snow, and two more enter through streams or ground water. Of these 4.5 feet of water flowing into the lake, 1.6 feet evaporate, and the remainder flows to the lower Great Lakes— at a rate of 75,000 cubic feet of water per second. One-seventh of this "output" is "input" by the St. Louis River.

Today, the St. Louis River appears to enter Lake Superior through the ship canal beneath the Aerial Lift Bridge, but this was dug artificially in 1870, and dredging is needed throughout the harbor to maintain depths necessary for large ships. The natural mouth of the St. Louis River is the "Superior Entry," an opening between Minnesota and Wisconsin Points.

The St. Louis River contributes not only water, but also reddish-brown clay, deposited by long-ago Glacial Lake Duluth and then eroded by lake storm winds and river storm runoff. Development and clear-cutting have led to increasing erosion along the river as well, and pollutants from municipal and industrial waste have led to the designation of the St. Louis River as an "Area of Concern" critical to the health of Lake Superior.

ST. MARYS RIVER

The St. Marys River is the only river to flow out of Lake Superior. It carries our water, and many added pollutants, to Lake Huron—and on to 23 million people who get their drinking water from the Great Lakes. The Great Lakes—of which Lake Superior is the headwaters—contain about 20% of the world's surface fresh water.

Despite the 75,000 gallons per day outflow through the St. Marys, Lake Superior requires more than 191 years for water to be flushed out of it, so that whatever we add to our lake remains for a very long time. In contrast, Lake Erie has a retention time of less than 3 years. This allowed the cleanup of the nearly "dead" Lake Erie over the past several decades.

The St. Marys River allows water and pollutants to pass *out* of Lake Superior, but also allows *in* ships and cargo. Since the Welland Canal was built to bypass Niagara Falls, ocean-going ships and all manner of exotic species have invaded Lake Superior; for example, the sea lamprey reached Lake Superior in 1938 and eventually helped to decimate the populations of lake trout and other large fish. The lake's annual lake trout harvest, which had averaged 4.5 million pounds from the 1920s through the late 1940s, fell to 0.5 million pounds by 1960.

BRULE RIVER, WISCONSIN

Today, the Brule River is a mecca for canoeing and trout and steelhead fishing.

Twelve and a half thousand years ago, the Brule River flowed OUT of Lake Superior into the St. Croix River and then to the Mississippi. Why? Because the last ice mass from the glaciers which carved Lake Superior into its current form had retreated only halfway back into the basin, impounding water into Glacial Lake Duluth, with a surface 500 to 600 feet above the present lake level.

FRENCH RIVER, MINNESOTA

Near the mouth of the French River is a DNR Fish Hatchery which serves the significant sport and commercial fishing industry on Lake Superior. Species stocked by the Hatchery include lake trout and steelhead (rainbow trout), as well as Kamloops, Coho and Chinook salmon.

A concern of both commercial and game fisherpersons, as well as residents throughout the Lake Basin, is the level of PCBs, a potent carcinogen. Because of PCB levels, the State of Minnesota sets advisory limits for fish consumption. See the Minnesota Fish Consumption Advisory (in the *Appendix*).

Minnesota recently lowered these limits—NOT because contamination had decreased, but because most people skin, trim away the fat and cook their fish fillets before eating them. This method of preparation reduces the amount of toxic PCBs—still considered one of the most serious toxic problems in Lake Superior fish.

KNIFE RIVER, MINNESOTA

A structure on the Knife River demonstrates a technique used to increase waters for spawning of game fish. Although Lake Superior is a cold, low-nutrient, oligotrophic lake and naturally produces significantly fewer pounds of game fish than the lower, warmer, richer Great Lakes, many people believe that waters suitable for spawning are the limiting factor for sport fish populations. North Shore streams tend to be relatively short and to abound in waterfalls which stop fish migration. In Knife River, as in many rivers along the North Shore, a few strategic barriers to migrating fish have been removed in an effort to increase natural reproduction of steelhead.

Charter fishing boats in Minnesota waters of Lake Superior are on the increase—there were 61 licensed charter fishing captains in 1992.

Recreational boating, like boating based in the Knife River marina, is on the increase as well. Between 1976 and 1984, the number of boats docked on western Lake Superior increased 83%.

CARIBOU BASIN: DEEPEST SPOT IN THE LAKE

Lake Superior is 1333 feet deep at its deepest point 40 miles off the shore at Munising, Michigan. One of the world's tallest buildings, Chicago's Sears Tower, could fit in that hole with only a few floors sticking above the water. This may not seem very deep, but Lake Superior is the largest lake measured by surface area in the world— it is 31,700 square miles. Its volume of water is tremendous, holding three quadrillion gallons—enough to flood all of Canada, the United States, Mexico and South America with one foot of water. Another deep spot is the 800-feet-deep North Shore Trench.

LAKE HURON

Next in line to Lake Superior in its drop to the sea, Lake Huron receives the only outflow of water from Lake Superior—75,000 cubic feet per second, or about seven times the flow of the St. Louis River as it enters Lake Superior. Lake Superior's surface is 602 feet above sea level; St. Marys Rapids fall 21 feet on their way down to Lake Huron. This natural barrier to navigation kept deep-draft ships from entering Lake Superior until the completion of the Soo Locks in 1855.

NIPIGON RIVER, ONTARIO

The largest tributary into Lake Superior, the Nipigon River is augmented by a diversion of water from the James Bay area to the north by way of Lake Ogoki and Long Lac. In the Canadian town of Nipigon, water is used for paper industries and for hydroelectric power. Diversion may seem a strange concept in our area, with ten percent of the world's fresh water within view of the lakeshore. However, Arizona and California, as well as other parts of the dry western U.S. have diverted so much of the Colorado River that it no longer flows into the Pacific Ocean—and major aquifers such as the Oglalla are being depleted for irrigation and development. Some people have already begun to dream and talk of diverting Great Lakes water (usually through an existing diversion at Chicago—would this affect Lake Superior?) to the thirsty southwest.

APOSTLE ISLANDS NATIONAL LAKESHORE

Extending east from Bayfield, Wisconsin, this area records a time in history over 800 million years ago, when shallow seas flooded the continental rift area and deposited sandstone sedimentary rocks. Much of the soft sandstone has eroded away now, forming a fine sand which is readily transported by lake currents—and has been deposited by the same in the world's longest freshwater sandbar—Minnesota and Wisconsin Points.

There are 22 islands in the National Lakeshore, and most have returned to a near-wilderness state after being logged and quarried in the 1800s and early 1900s. The Apostles are now a favorite destination of sailors and sea kayakers.

PICTURED ROCKS NATIONAL LAKESHORE

Extending east from Munising, Michigan, the Lakeshore records a time in history (over 400 million years ago) when saltwater extended into the continent and deposited limestone, shale and sandstone sedimentary rocks. The Grand Sable Dunes in the eastern part of the Lakeshore developed from the terminal moraine of a glacier that came over Lake Superior from the north; over the millenia, entire forest ecosystems have developed on the dunes only to be buried in the shifting sand.

WATERSHED

Minnesota includes parts of three major watersheds which meet at a point northwest of Duluth: the Mississippi River begins in Itasca and drains into the Gulf of Mexico; the Rainy and Red Rivers flow northward from western Minnesota into Hudson Bay, and the Lake Superior Basin flows eastward to the Atlantic Ocean. Much of the city of Duluth could be said to be in the St. Louis River watershed, the Lake Superior Basin watershed, the Great Lakes watershed, the St. Lawrence River watershed and the Atlantic Ocean watershed. The Lake Superior Basin covers 49,300 square miles—small for the size of the lake, which is 31,700 square miles.

PARK POINT (MINNESOTA POINT) AND WISCONSIN POINT

Opposing currents have built Minnesota and Wisconsin Points because suspended sand (eroded from sedimentary rocks formed a million years earlier at the Apostle Islands and Pictured Rocks) was deposited where river currents met lake currents. This bay-mouth sand bar is largely responsible for the fine harbor at Duluth and Superior. Both points have specialized habitats with distinctive flora and other endemic species (species occurring only on the Great Lakes) such as the endangered piping plover (currently extirpated in the St. Louis River estuary). As the plover's plight indicates, both points have been threatened by overuse and development.

HAWK RIDGE, MINNESOTA

The "ridge" is actually the former shoreline of Glacial Lake Duluth from 10,000 years ago. Today it is used by hawks for its uplifting winds, especially during fall migration. Up to 75,000 hawks per year can be seen migrating along this ridge of land rising above Lake Superior.

WHITEFISH POINT, MICHIGAN

Whitefish Point is a renowned site for observation of many birds during spring migration. Can you explain the seasonal differences between Hawk Ridge and Whitefish Point by studying their locations on the map?

ISLE ROYALE WILDERNESS NATIONAL PARK, MICHIGAN

Famous for hiking, boating, fishing, wolves and moose, Isle Royale's pristine and undeveloped state belies its exposure to human activities. Even the isolated lakes in the center of this island contain measurable amounts of toxaphene, an insecticide used mainly in the south on cotton crops, but banned in 1983 when it was discovered to be a carcinogen. The inescapable conclusion? Atmospheric transport is the major source of pollution for Lake Superior. Atmospheric pollutants account for over half (some say 95%) of the pollutants entering Lake Superior.

PUKASKWA NATIONAL WILDERNESS PARK, ONTARIO

Pukaskwa is a Canadian National Wilderness Park comparable to Isle Royale National Park in the United States. The park preserves a wilderness shoreline with the Canadian highway routed well inland, providing a unique area of very little development. The park has an extensive lakeshore hiking trail and provides a stunningly beautiful water trail for kayakers, canoeists and sailors as well!

"THE BARRELS"

Nine of the 1,457 barrels dumped between 1957 and 1962 have been brought up from a location off the shore of Lester River in Duluth, Minnesota. The barrels contain military munitions waste: hand grenade, rocket and other parts mixed with concrete slag and ash. The scrap came from the Honeywell munitions plant in the Twin Cities. As you study the map, keep in mind that Duluth's water intake pipe reaches out into the Lake 1 mile upshore from the Lester River!

UNDERWATER

Recreational SCUBA diving is growing in popularity. Lake Superior waters are very cold but very clear, and they contain the remains of many ships which have gone down in November storms. The Minnesota north shore harbors five shipwrecks, while the "Shipwreck Coast" near Munising has many more, preserved as the lake's only underwater park.

Sturgeon Stories

What is the life of a Lake Superior sturgeon like? Migrate down a stream to swim in the open lake, return and spawn—and understand how the sturgeon fits into the lake's web of life.

TOPIC
The life cycle of the sturgeon, Lake Superior's largest fish.

SETTING
Requires a large space, such as a gym or outdoor field.

AUDIENCE
15-45 students, depending on age (a smaller group if under age 9 or a larger group if over age 9)

LENGTH
30 minutes

GOAL
To understand how the sturgeon fits into the Lake Superior web of life.

OBJECTIVES
- *Students will be able to state some basic facts about sturgeon such as size, life cycle stages and role in the food web.*
- *Students will experience how natural and human forces impact sturgeon populations.*

MATERIALS
- *6 orange cones to mark boundaries (or anything else suitable)*
- *2 shoe boxes ("boats" for the anglers)*
- *2 pretend fishing poles*
- *approximately 150 cards to represent food (1/3 of the cards marked with an X to show pollution), held inside a cardboard box with a hole just large enough for a hand to get in and feel around for the cards (same cards as used for "Food Chain Tag")*
- *jumprope or broom handle to do a limbo*
- *(Optional) drawing or illustration (ideally life size) of a sturgeon*

BACKGROUND

Sturgeon are the largest fish found in Lake Superior, weighing up to 330 pounds and measuring up to 7 feet long. Their skeleton is made mostly of cartilage and their scales are reduced to bony plates; these features indicate that sturgeon are one of the most ancient fish known. They are mostly bottom feeders, using their whisker-like barbels to feel for fish and crayfish as well as mollusks, aquatic insect larvae, and aquatic vegetation.

Sturgeons spawn in slow-moving rivers; in the western end of Lake Superior there are naturally reproducing sturgeon populations in the Bad and Ontanagon Rivers, and efforts are underway to get sturgeon spawning in the St. Louis River once again.

Sturgeon were valuable sources of food for Native Americans. Early commercial anglers saw sturgeon as a threat and would kill sturgeon by the hundreds. After 1860, they were overfished for their valuable meat, oil, and eggs (caviar). Finally, during the peak of logging in the Lake Superior basin, sawdust and floating logs fouled their shallow shoreline habitat. These factors combined to lead sturgeon to the brink of extermination from Lake Superior.

Note *The Living Lake Superior* background section for more sturgeon information.

GETTING READY

Set up the playing field as shown in the diagram on page 87 of this lesson.

PROCEDURE

1. Introduction

Discuss with students background information about sturgeon. Explain that sturgeon spawn in streams and because of this, they face many obstacles in life. Show students the illustration of a sturgeon, if available. If not, explain that the typical adult sturgeon is about the size of a typical fifth grader!

2. First obstacle: downstream migration

Have the students think of what the obstacles might be for a young sturgeon going downstream to Lake Superior. Ask for two volunteers to be predators in the downstream area. Have students brainstorm on what types of predators they might be (possibilities include black bear, heron, large fish). Tell all other students that they are sturgeon and must make it past the predators to get into Lake Superior. They are dead if a predator tags them, and must leave the playing area.

BEST COPY AVAILABLE

3. Second obstacle: life in Lake Superior

Once all the sturgeon have tried the first obstacle (some may have been "eaten") select two more volunteers to be anglers. Selecting from those who were caught in the first phase gives them a way to participate.

In this section the sturgeon must collect three non-poisoned food tokens to get through. Place the tokens in the box on one side of the field. Explain that each food token represents seven years worth of food. The box is placed on the ground, and the players have to reach in and feel around, because sturgeon are bottom-feeders. Explain that sturgeon use their barbels to find food in the dark bottom waters.

Sturgeon must run back and forth to collect food in front of the anglers without being touched by the anglers' poles. Sturgeon may only grab one food token at a time and if it is poisoned they must make an extra trip across the lake. Anglers must keep one foot in their "boat" (one of the boxes) at all times, although they can shuffle the boats to move within the playing field.

Before leaving this obstacle, explain to students that it is only after collecting all those "years" worth of food that the female sturgeon reaches sexual maturity, that is, is able to spawn. Ask students how many years the three food tokens they picked up represent, now that they're ready to go back up the river and spawn (Answer: 21 years).

4. Third obstacle: upstream migration

In the next section the sturgeon move out of Lake Superior and head back upstream to spawn. Two more volunteers will be needed to hold a limbo bar at about chest height. This represents a fish ladder. Explain that a fish ladder is a series of pools built around a dam so that fish can continue to swim upstream. Sturgeon are often too large to use them so both dams and fish ladders are a serious obstacle for them. Sturgeon must do the limbo underneath the bar. If they fall or touch the rope they die and must exit the playing field.

5. Wrap-up

Sturgeon who make it past all the obstacles survive into adulthood and are able to reproduce. Only a few sturgeon will probably survive all of the obstacles. Lead a discussion on the different phases of a sturgeon's life cycle. Ask students what the toughest parts of a sturgeon's life were.

ASSESSMENT

During the wrap-up, ask what humans could do to help the sturgeon. Some potential answers are: avoid polluting Lake Superior, make fish ladders on streams big enough for sturgeon, and avoid overfishing sturgeon.

EXTENSIONS

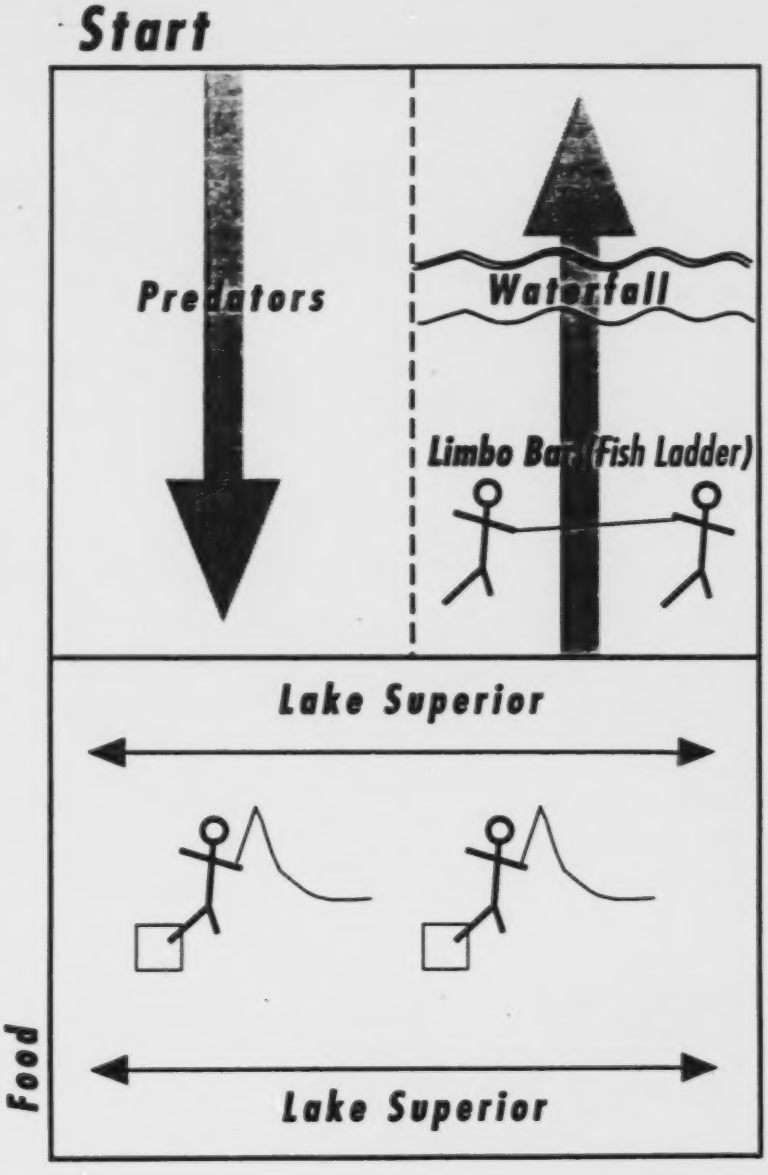
Younger students will often want to go through the obstacles a number of times.

REFERENCES

Information from *Fish of Lake Superior*, by the University of Wisconsin Sea Grant College Program.

"Watch Me Grow" poster from Wisconsin DNR Bureau of Fisheries Management, P.O. Box 7921, Madison WI 53707.

"Sturgeon Stories" Playing Field



You "Otter" Be There!

Dress up a student as a river otter and, in the middle of the laughter, learn about animal adaptations to life on Lake Superior.

TOPIC
River otters, animal adaptations.

AUDIENCE
Grades K-8, 5-60 students

LENGTH
20-30 minutes

GOAL
To recognize the otter as an animal of Lake Superior and value its role in the Lake Superior food chain.

OBJECTIVES
- *Students will learn the word "adaptation."*
- *Students will learn 3-5 adaptations of the river otter.*

MATERIALS
- *chalkboard or other visual aid*
- *cheap fake fur coat*
- *oil can or tube of waterproof grease*
- *long "tail" (a scarf works well)*
- *goggles*
- *fur cap with fake eyes fastened on top*
- *"whiskers" and nose*
- *gloves with "webbing," e.g. swimmer's webbed gloves*
- *odor container: plastic film container with cotton ball soaked in skunk and/or fish oil odor.*
- *3-4 clothespins for attaching things and for modeling nose-plugging abilities*

BACKGROUND

In order to survive in their environment, all organisms have adaptations. An adaptation can be a physical feature or it can be a behavior. Adaptations are tools for survival. For example, a river otter is adapted to its environment through physical adaptations such as thick fur and whiskers, nictitating membranes over the eyes, the ability to close off the nose and ears for underwater exploration and through behaviors such as sliding across snow. The toes are fully webbed. The river otter is one of the few mammals associated directly with Lake Superior's water environment. Otter families may range along 50-100 miles of shoreline, but usually stay within a five to ten mile stretch at any one time. Otters feed on fish, crayfish, and other small water critters. They appear to spend much of their time simply playing, sliding, swimming, and chasing things.

PROCEDURE

1. Introduction

Introduce or remind students of the concept of adaptations. A good working definition is "A characteristic that a plant or animal has which helps it survive better in its environment." Lake Superior is a unique environment. Ask "If you were going to live around Lake Superior, what are some of the conditions to which you would have to adapt?" (water, cold, ice, human pressure, etc.)

Explain that the class is going to create an animal that's perfectly suited for one particular Lake Superior environment: the rocky shoreline. Explain that this will be a warm-blooded animal that eats fish. Ask students not to guess the name of the animal until the end.

2. Dress up

Recruit one brave volunteer. Bring that student forward and get them up on a platform, chair, or table. This student is now the "mystery animal."

Ask the group what the creature would need to stay warm. Pull out the fur coat and have the volunteer put it on.

Remind students that this animal is a fish-eater—where are the fish? (in the water). If the animal goes in and out of the water, its coat will get wet. How can the animal keep its fur dry? Pull out the oil can and have the student demonstrate glands that keep the fur from getting soaked.

Once in the water, how will the mystery animal move around? (add tail). How could we make those hands better for moving around? (add webbed gloves). How will the mystery animal see around? (add cap with eyes on top to show "predator" eyes). Compare eyes on the front of the head like those of people and otters with

"prey" eyes, which are usually on the side of the head like a mouse or deer. How will the eyes be protected underwater? (add goggles to represent the nictitating membrane over its eyes to protect them underwater).

What about when the water is murky? (add whiskers). How can we keep water from going up the nose and into the ears? (clothespin, ear muffs).

3. Review adaptations

Before taking off the costume, review each part by asking the class what each part is for, i.e. what the adaptation is. This could be written up on the board, or older students could create a table on their own paper. Have the students guess what the "mystery animal" is. Give some background on otters, on how playful they are, etc.

4. Something's smelly

Back up on land: As you can tell, if you've seen one otter, you've seen them all. How can otters tell each other apart? Hint: otters are in the Mustelid family (write "Mustelid on the board), meaning "musty" or "stinky." Pass around odor container. They can smell the difference even when they can't see the other otter.

5. Wrap-up

We've created the perfect animal for its environment. Explain that one problem is that the environment is changing. For example, the Lake Superior fish are contaminated because of airborne pollutants and bioaccumulation.

Ask: what adaptations could we give the otter to best deal with a polluted lake or contaminated prey base? Could we give the otter a water purifier? Could we take it shopping to the grocery store? If we're going to take care of the otter, we have to take care of the lake.

ASSESSMENT

As a homework assignment, assign students another Lake Superior animal and have them come up with their own "props" for this animal.

EXTENSIONS

- Do a comparison of river otters and sea otters. Use the book *Sea Otter River Otter*, by Sandra Chisholm Robinson.

Reforesting Superior

How important are trees to the health of Lake Superior? Turn ideas into action with this activity that teaches about regional vegetation, and gets kids outside to plant some trees!

TOPIC
Community Environmental Restoration and Lake Superior. The activities presented here are designed specifically for Lake Superior North Shore communities, such as Duluth. The concepts can, however, be adapted to other locales.

AUDIENCE
Grades 3-8, 15-30 students

LENGTH
Highly variable and dependent upon site specifics

GOALS
- *To make a connection between the health of the vegetation and the health of the lake.*
- *To contribute to the health of Lake Superior via environmental service. In doing so, students will have the experience of making a positive difference in the health of the community.*

OBJECTIVES
- *Students will be able to describe, in approximate terms, the geographic watershed of Lake Superior.*
- *Students will be able to describe how planting trees and other vegetation is beneficial.*
- *Students will be able to identify at least three trees native to the highlands of Lake Superior.*

MATERIALS
- *watershed maps (one per student)*
- *colored pencils*
- *trees and tree planting equipment (see procedure)*
- *Giono, J. (1985). The Man Who Planted Trees. Chelsea: Chelsea Green.*

BACKGROUND

Most of the forests that surround Lake Superior have at one point been logged completely or partially. Understanding what was there and was is there now is an important part of understanding the whole living Lake Superior. While this lesson focuses on the native forests near Duluth, it works as well for locations around the lake.

Restoring a small plot of maple, basswood, yellow birch, white pine and northern white cedar species is important in the spirit of reclaiming the environmental history of the hills that rise above Lake Superior from Duluth to Canada, "the Superior Highlands." These species provide an approximation of the pre-settlement vegetation of the region's northern hardwood/conifer mixed forest. This forest type is primarily restricted to a narrow band along Lake Superior. The Minnesota Department of Natural Resources has confirmed the rarity of virgin stands of northern hardwoods, existing only in remnant stands. The Nature Conservancy identified the Highlands as one of the 24 most diverse landscapes in Minnesota in 1992. The Conservancy also points out that it is the mostly continuous cover which provides an amazing amount of shelter for birds and other animals; an analysis of breeding birds in Minnesota found that the Highlands are home to more breeding bird species than any other major landscape in the state. North Shore communities can encourage the benefits of continuous vegetative cover via careful city land use and city plantings that maintain environmental integrity.

GETTING READY

Prepare copies of the watershed map.

The following steps must be taken in advance of the actual planting:

- Identification of a site for the tree planting. A site may be a part of a school campus, a city park, a nursing home yard, a state park location, etc. Wherever the site, it will require permission and land use planning.
- Tree ordering. An inexpensive and reliable source of appropriate tree species is your local Soil and Water Conservation District (in Duluth, the South St. Louis County SWCD). Orders to the SWCD are typically accepted during the winter and the actual trees are made available during the month of May. The costs involved (based on the 1995 figures) are approximately $22 to $25 for bundles of 25 trees of a single species; these trees arrive in small sizes varying from 5" to 12." In 1995, the maple, oak, pine and cedar

highland species were available. In order to obtain the yellow birch and basswood, General Andrews Department of Natural Resources Nursery must be contacted. Basswood trees must be ordered very early in the winter, as their availability is limited; yellow birch can be ordered in groups of 100 for approximately $45.

- Planting preparation. Trees, planting bars and shovels need to be lined up in advance. Tools can be solicited from greenhouses, city works departments, state parks, etc.

PROCEDURE

1. Getting familiar with the watershed

Provide students with a copy of the watershed maps and instruct them to color the land and water two different colors (green and blue or purple and orange, etc.). Discuss the concept of watershed. Provide students with a variety of U.S. and Canadian maps. On their watershed map, ask students to label one U.S. National Park, one Canadian National Park, one U.S. state park, one Canadian provincial park, three U.S. cities, three Canadian cities, two peninsulas and all of the states and provinces that border on the lake.

2. Hiking the watershed

Lead a hike, preferably directly from the school (if possible) to a nearby neighborhood. Identify storm sewers. Discuss where all the water that drains into the sewers goes...Lake Superior! It is important to stress that rain and other items may be on the highlands one day, and then washed into the lake the next! If possible, a city lakeshore hike to actually see some of the storm sewer lake drainage sites would help create an ideal experience. Most Lake Superior cities have a wealth of streams and creeks that drain into Lake Superior, providing further examples of watershed drainage.

3. Tree tour!

Prior to a tree hike, discuss with students that much of the high hilly land rising up from Lake Superior was once covered in a unique rich forest type. In the case of the Minnesota north shore, the forest type is referred to as "the Superior Highlands forest." The tree species that predominated the highlands include: sugar maple, yellow birch, basswood, northern white cedar and white pine. If possible, get out and hike to specimens of these tree types or provide pictures for the students.

4. The Man Who Planted Trees

It is important to help the students make the link that vegetative health in a watershed is directly related to water quality. Read and discuss the book, both the elements of the roles trees play in watershed health, but also the role people can play as stewards—hence making the bridge to environmental service. Just as the man in the story reclaimed damaged land, students can think of themselves as reclaiming land to restore it to a more natural setting. Youth see land altered for roads, malls, stores and other such development all the time, thus it is exciting to think of students as having the chance to see land being reclaimed for reasons other than human economic development.

5. Forest Planting

Tree planting should be discussed with students prior to their actual involvement. The Soil and Water Conservation District provides proper tree

planting information with their tree orders. It is a valuable experience to involve students in the ordering of the trees, i.e. filling out forms and computing costs, if at all possible.

The final activity is the actual planting of a highlands forest plot. The actual planting should be a celebratory event—complete with fanfare, picnicking, and merriment. Students should be encouraged to think of their work as necessary, important, and enjoyable!

ASSESSMENT

Observe student motivation throughout the project. What motives do they express for following through on the project?

EXTENSIONS

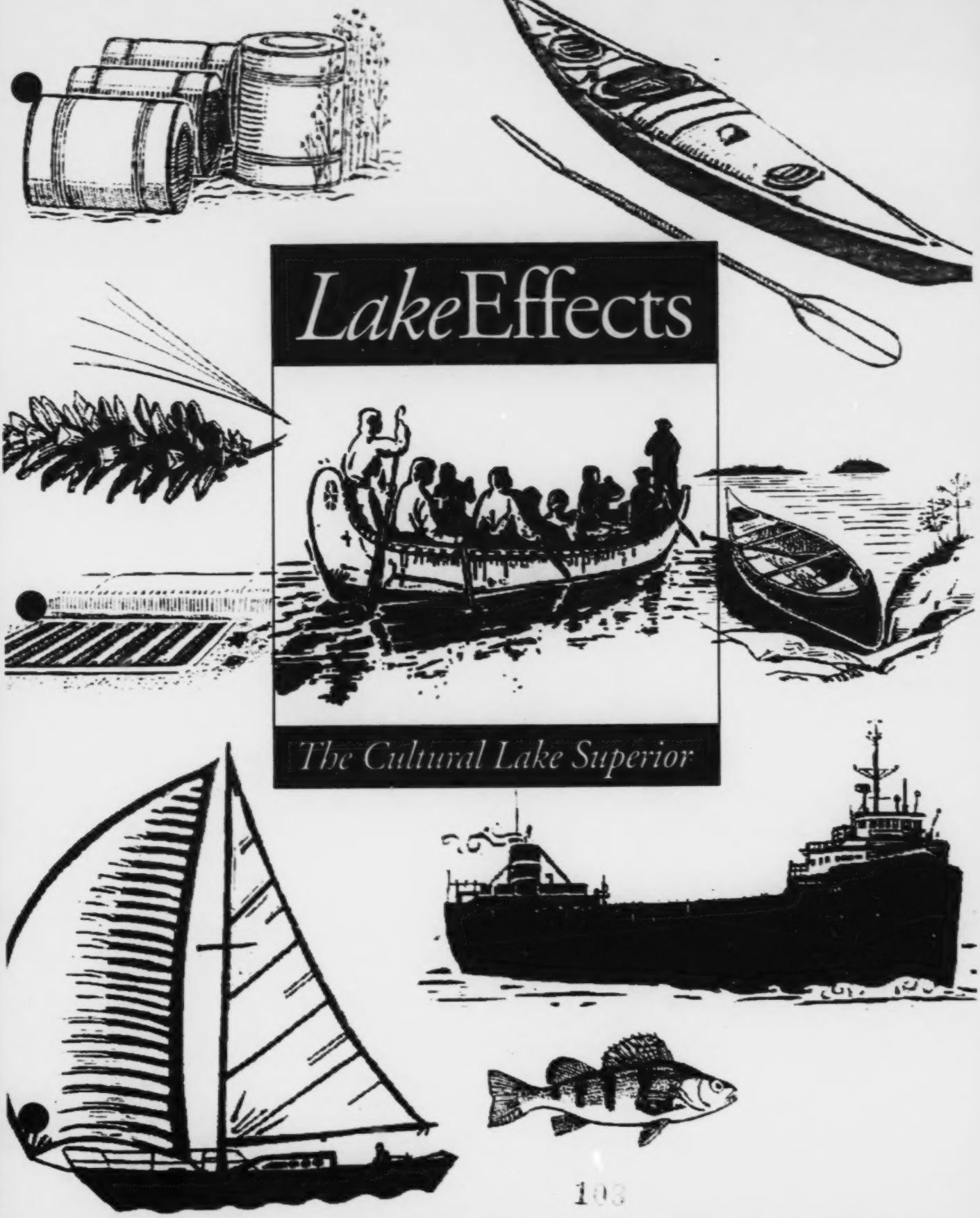
- Yearly tree plantings.
- Wildflower plantings of native highland wildflower species. (Both of these previous two ideas can extend a one-season event into an ongoing educational experience)
- Herbivore and people protectors; some sites may require close attention to the protection of the trees in order to insure a viable level of survival. An example of potential protection are Tubex tubes—these degradable plastic tubes prevent herbivores from browsing on new trees as well as provide a marker to prevent human damage to the plantings.
- Forest mapping—students can map and chart their plot of forest.
- Who and what lives in your forest? Research it!
- The National Arbor Day Foundation and Project Learning Tree are just two possible sources for comprehensive plant/tree curricula.

REFERENCES

For ordering information:

S. St. Louis SWCD, 4850 Miller Trunk Highway, Suite 1-B, Duluth, MN 55811

General Andrews DNR Nursery, P.O. Box 95, Willow River, MN 55795


LakeEffects
The Cultural Lake Superior

Although the settlement of Europeans into the Lake Superior region occurred only after thousands of years of Native American settlement and involved great conflict, today descendants of both cultures share in the beauty and resources of this area. Today, as the heroes from exploration, the fur trade and earlier—from the Anishinabe to the Finns—are celebrated in legendary tales and an ever increasing historical understanding, an appreciation for all of the cultures of this region can be achieved.

The cultural Lake Superior, however, is more than the story of the people who have lived along its shores. Too, it is the story of how those people and the lake have interacted over time. Humans have affected the lake and the lake has affected its people.

FIRST AMERICANS

European involvement in the Lake Superior region comprises only 5% of human history in the area; we know very little about the first several thousand years. What is available is information recovered by archaeologists from burial sites and some settlement areas, with much remaining as speculation.

After the glaciers receded, people began to inhabit the Lake Superior region. Though the lake was physically very similar to its present state, its residents were not. The first humans along the shore were contemporaries of the woolly mammoth, as well as a much larger species of beaver and the giant bison.

This first group of people given a name arrived in the area approximately 2000 years ago. They are known to archaeologists as the Laurel culture. Though they did not live right on Lake Superior's shores, their burial mounds have been found in northern Minnesota. The mounds are very large and apparently were generational tribal graves. Copper artifacts found at burial sites have been linked to Lake Superior's copper mines. Archaeologists also speculate that it was the Laurel culture that first used bows and arrows in the Great Lakes region.

About 1200 years ago the Blackduck culture arrived in the Lake Superior region. At this point the Laurels had either migrated, been driven out, died out, or had possibly been assimilated into the Blackduck culture. The Blackduck lifestyle was very similar to that of the Native Americans when the Europeans first arrived on Lake Superior's shores. For example, the Blackduck people were the first of the wild ricers in the region.

As the Europeans were settling on the Atlantic coast, ancestors of the Dakota moved north and pushed the Blackducks north and west of Lake Superior. The Dakota settled to the south and west of the lake, leaving the north shore uninhabited.

With the settlement of the Europeans to the east came guns to the Iroquois. With this to their advantage, the Iroquois drove out their long-standing Algonquian enemies which included the large Anishinabe tribe. Along with the Ottawans and Potawatomi, the

Anishinabe moved west to the eastern shores of Lake Superior. This was the geo-political situation among the Native Americans of the area when the Europeans arrived to the region.

The word "Anishinabe," which for many is the preferred name of these people, means *first people*. Other common Anishinabe names include Chippewa and Ojibwe (Ojibwa, Ojibway) refering to a style of "gathered" or "puckered" moccasin worn.

There is evidence to indicate that a division of Anishinabe people occurred at Sault Ste. Marie. One band of the people moved north and west along Lake Superior, with the other following the south shore west; this southern movement eventually reached the Apostle Island area with a center of trade and culture at La Pointe, Wisconsin (Madeline Island).

■ ANISHINABE CULTURE

Before the time of the Europeans, the Anishinabe lived a seasonal lifestyle, moving from site to site depending on what food was available. In the fall and spring, fish were caught with nets or speared and either dried or smoked. Maple sugar was made in late March or early April. The men collected sap in birch bark buckets and the women heated the syrup and paddled it into sugar for use as a seasoning. Since the Anishinabe had no salt, they used the sugar to season fruits, venison and fish.

Traditional berry patches and gardens were home to tribes during the summer, especially those near water for fishing. Village gardens provided corn, squash and pumpkins. After the summer harvest, small groups would move to wild rice lakes. The ricing was usually done with men and women working together in birch bark canoes.

Hunting was also very important for the Anishinabe. Bows and arrows were used to hunt water fowl and traps were used for small game. The meat was sometimes dried and saved for spring when food was often scarce.

Each family also owned several birch bark canoes weighing 65-120 pounds (30-55 kilograms). The canoes were valuable for the harvesting of wild rice and traveling to new sites. Land travel was much more difficult than moving by water in the Lake Superior region; waterways had long been important highways for the first Americans.

When the Europeans arrived on Lake Superior's shores, the Anishinabe were open to their fur trade. Early on, the Anishinabe were on friendly terms with the French explorers and traders. The French understood the Anishinabe concept of gift-giving. The greatness of a person was measured by what was given away, and not by what was kept for oneself.

When the British took over the region from the French, they refused to give the Anishinabe gifts, calling it shameful "charity." The Anishinabe considered the British rude, and for this and other reasons they sided with the French during the French and Indian War. During the American Revolution, however, the tribe sided with the British who allowed them to maintain their autonomy in the still rugged area.

ONTO THE RESERVATIONS

The American government, aft. the Revolution, immediately began making plans to move the Anishinabe west of the Mississippi. They refused and the government abandoned the plan. Instead, homelands, or reservations, were set up for the tribes around Lake Superior. The two largest groups of Anishinabe living in the Lake Superior region today are those on the Nipigon (Red Rock) and St. Louis Rivers (Fond du Lac). Other reserves and reservations around the lake are Bad River and Red Cliff, Wisconsin; L'Anse, Ontonagon and Bay Mills, Michigan; Grand Portage, Minnesota; Garden River, Pic River, Pays Plat and Fort William, Ontario.

Today the 200,000 Anishinabe are scattered as far west as Montana and north into Canada. The yearly harvesting of wild rice has proven to be a uniting factor for all the Anishinabe, even across political boundaries. Many Anishinabe return to the Lake Superior area for the traditional gatherings that are part of their heritage.

EXPLORERS, TRADERS AND VOYAGEURS

In about 1623, Etienne Brule and Grenoble, in the employ of the Governor of New France, were the first Europeans to see the Lake Superior region. They were searching for a mythical route to the riches of the Orient. French exploration continued in the region as the fur trade began to develop; the beaver pelt was the much sought after prize.

Trading and exploring went hand in hand. As eastern furs became scarce, French explorers headed west in search of new economic territory. Radisson and Groseilliers secretly left for Lake Superior without a permit from New France in 1659. They traveled through Sault Ste. Marie and wintered on the south shore of the lake, near Ashland, Wisconsin. They befriended the Native Americans living in the area and lived profitably trading furs. The next summer they headed up the north shore with Anishinabe assistants.

When Radisson and Groseilliers eventually headed home they had sixty canoes full of furs, valued at $300,000. Unfortunately, because their trip had been unlicensed, they were arrested once they reached Quebec and their furs were confiscated. Though they were treated like criminals, they had indeed accomplished an historic feat. They had set up contacts among the Native Americans without which future travelers would have never been able to accomplish exploration and business in the wilderness.

Claude Jean Allouez, a Jesuit missionary, traveled the western end of Lake Superior in 1667 on his celebrated mission of mercy to the Nipissing Indians on Lake Nipigon. His birchbark canoe travels helped in the drawing of the Lake Superior map published by Jesuits in 1672. Jesuit missionaries also arrived in the hopes of converting the Native Americans. By 1670, the Jesuits had produced a relatively accurate map of Lake Superior.

The first printed map that showed the Great Lakes in their entirety and the

most accurate portrayal of the lakes and their tributaries in the 17th century, was Coronelli's map of Western New France in 1688. This named Lake Superior as Lac de Tracy after the Governor of New France, or Lac Superieur or Lac de Conde.

■ WAR AND PEACE

Daniel de Greysolon, Sieur du Lhut, was an important explorer of the time. In 1679 he canoed from Sault Ste. Marie to Fond du Lac ("Head of the Lake") which is now known as the Duluth/Superior area, then up to Grand Portage where he established a post for the fur trade. On this expedition he was involved in the negotiations which established a fifty-year peace between all Indian tribes within a 200 mile radius of the western end of Lake Superior, Fond du Lac. The negotiations allowed the Anishinabe to become the middle-men for the fur trade, and in a sense, the real voyageurs.

The peace was broken after a massacre by Plains Dakotas in search of missing supplies at Lake of the Woods. The Anishinabe retaliated against the Woodland Dakota for the murder of the French explorers. The ensuing battles resulted in the Anishinabe having full control of the Lake Superior region and involvement in the fur trade.

After the French and Indian War, the Treaty of Paris in 1763 ceded the region to British control. This created conflict between the two trading companies—Hudson's Bay Company and North West Company. The North West Company was located in the more rugged terrain around Lake Superior and was comprised of many of the remaining French voyageurs. The completely British Hudson's Bay Company was easier for traders to reach. Rivalry between the two companies escalated into bloody battles until 1821 when the two companies merged.

The American Revolution brought about the creation of John Jacob Astor's American Fur Company. The advantage to this company was that Grand Portage lay on American territory (Grand Portage provided an essential link to the inland waterway system). A duty tax was charged on all British traders using the trail. Soon, the British were forced to use a more difficult route to the interior of beaver territory, canoeing upstream and around falls. The American Fur Company thrived during this period.

■ THE VOYAGEUR

One legendary player in the intense fur trade was the voyageur. Most of these men, the paddlers and pack carriers, were only 5 feet (1.5 meters) tall or less. They had a slight but wiry build and were able to carry several pallets weighing more than 90 pounds (41 kilograms) apiece!

In the early years the voyageur dressed in tanned hides and moccasins like their Native American friends. Later they adopted practical cloth garments with colorful sashes and stocking caps with tassels. Most of the voyageurs were known to have similar dispositions and personalities and smoked tobacco from clay pipes. Singing was perhaps the most important aspect of

keeping a voyageur's morale up throughout such hard work. Many of the songs were synchronized with brisk paddling. One such well-known song is "Alouette." So important was singing that strong lead singers were even paid a bonus.

The voyageurs lived among the Native Americans learning their customs and traditional way of life. At first the tribes were wary of the Europeans. The voyageurs eventually began to marry women from the tribes and were accepted into the Native American communities. Some considered the tribal men equal as their brothers. This relationship was markedly closer than that between the British and the Native Americans.

The decline of the era of the voyageur came as a result of a number of factors: overharvesting of the fur-bearing mammals meant an ever growing amount of effort was required to bring the furs in; fashions in Europe were changing (for example, the beaver felt used in the making of fashionable French and English top hats was replaced by silk); the economy was changing, resulting in logging and mining emerging as profitable endeavors; and finally, transportation changes slowly began to reduce the importance of the canoe.

STORMY WATER AND SUNKEN SHIPS

Because of the storms that whip up on Lake Superior, Anishinabe people have a legend that Superior "never gives up its dead". This has proven true in several instances with shipwrecks that have occurred, especially on stormy November waters. The first recorded shipwreck was August 26, 1816, when a sail-equipped canoe capsized off Parisienne Island, northwest of the Soo. Nine to eleven of the 24 passengers drowned, including a North West Company bourgeoisie, soldiers and Iroquois paddlers. The first recorded American total vessel loss on Lake Superior was the *John Jacob Astor* on September 21, 1844, while it was anchored at Copper Harbor, Michigan. Since then, 350 total vessel losses have occurred on the lake with over 1,000 human casualties.

Perhaps the most famous shipwreck was the *Edmund Fitzgerald* on November 10, 1975. The *Fitzgerald* was the largest iron ore ship on the Great Lakes at the time. It was believed that such a large ship would be able to weather the lake's winter storms, so ice cutters kept the shipping season open until December. The *Edmund Fitzgerald*, however, sank just off Whitefish Point. In July of 1995, the *Edmund Fitzgerald's* bell was raised from the sunken ship to be placed at the Great Lakes Shipwreck Museum in Whitefish Point, Michigan. The bell will be a memorial to the 29 crew members who perished with the *Edmund Fitzgerald* as well as to all mariners lost in shipwrecks on the Great Lakes.

103

GATEWAY TO THE WORLD

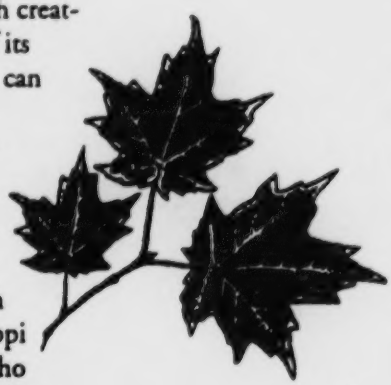
Compared to the other Great Lakes, Lake Superior's population of approximately 700,000 people is very small. Thunder Bay, Ontario and Duluth, Minnesota/Superior, Wisconsin are the most heavily populated areas. It is, in part, the cold winter temperatures, as well as the rugged terrain, that keep the region's population low. It is the low population and relatively low levels of industry that keeps the lake unique in its relative purity.

Today, Americans, Canadians and Anishinabe live along Lake Superior's shores still dependent upon the industries of shipping, mining, timber, fishing and wild rice. However, tourism has also become an economic force in the region. Lake Superior is used for sustenance and recreation.

The lake is an important global resource, serving the needs of people locally and internationally. Ships from all over the world come to the ports of Duluth/Superior and Thunder Bay to deliver goods and pick up iron ore, grain and container goods. Shipping is the gateway to the world for many products. In fact, cargo shipping is cheaper and less environmentally destructive than other forms of transport, like trucks, planes and trains. Lake Superior is connected to the Atlantic Ocean by the St. Lawrence Seaway. The 2,343 mile (3,772 kilometer) trip for cargo ships from the Duluth/Superior harbor to the ocean takes seven days.

LAKE SUPERIOR AND THE ARTS

The cultural Lake Superior is also the Lake Superior of poetry and painting, songs and stories. The Ojibway told stories in the wintertime, and the hero of many of their stories was Nanabozho, a magical, sometimes mischievous character credited with creating Lake Superior and many of its most scenic places. Nanabozho can be seen today in the "Sleeping Giant" formation of the Sibley Peninsula, visible from Thunder Bay.



After Henry Schoolcraft, an early European explorer of both Lake Superior and the Mississippi River, published the Nanabozho tales, Henry Wadsworth Longfellow adapted the stories for his "Song of Hiawatha," with its famous line "By the shores of Gitche Gumee/By the shining Big-Sea-Water." This thread of the cultural Lake Superior went as far as paintings by the world-reknown landscape artists Albert Bierstadt and Thomas Moran.

Early in the 1900s, a group of Canadian painters were drawn to the wild shores of Lake Superior. This "Group of Seven," which included Lawren Harris and J.E.H. MacDonald, painted fiery impressionistic landscapes of Lake Superior scenes. These paintings brought recognition to Lake Superior from throughout the world.

Musically, Lake Superior is best known through the haunting ballad "The Wreck of the Edmund Fitzgerald," by Gordon Lightfoot. The photographic work of Craig Blacklock, Charles Steinhacker and others have brought further reknown to the lake.

ENVIRONMENT AND CULTURE

Lake Superior has always been a source of intrigue to those far away and a source of pride to those on its shores. From its first "discovery" by Europeans looking for the Northwest Passage to China, Lake Superior has been influenced by events and trends that occur in distant places. The same is true for the problems and issues facing Lake Superior today. Atmospheric deposition of toxins and fresh water diversion to the arid plains and southwest U.S. are real environmental threats to the lake, although hard to perceive. The increasing recreational pressures from communities within and outside the basin are threatening the lake with being "loved to death."

The environmental history of Lake Superior can be read as a gradual change of what is perceived to be valuable. The Native Americans found in Lake Superior a ready source of food and transportation. Early Europeans explorers valued either beaver skins or human souls, and found plenty of both. In the midst of the fur trade, the lake itself was also discovered as a resource, as the first commercial fishing ventures were set up under the control of the fur trading companies.

Beginning in the middle 1800s, timber was first cut in the Lake Superior basin on a commercial scale. Timber companies, looking primarily for white pine, came from the Michigan area. When Michigan had been exhausted of its white pine supply, the timber companies looked across the lake to Minnesota. For many decades, white pine were cut on the Minnesota shore and transported across the lake to mills in Wisconsin and Michigan.

Another industry which rose in the 1800s was mining. Copper mining in the Keweenaw and silver mining on the Canadian north shore began in earnest. Later in the 1900s, the iron ranges of northeastern Minnesota were opened up. In the history of mining and its environmental impacts on Lake Superior, perhaps no story is more famous (or infamous) than that of the Reserve Mining Company (treated in detail in the lesson "Unreserved Judgement").

Also in the middle 1800s, the resource of tourism on Lake Superior was first tapped. Visitors were lured to Lake Superior in much the same way as visitors are lured now to Alaska: cruises on the final frontier. Early "eco-tourists" visited the scenic splendors of the north and south shores by the only mode of transportation available, the boat.

The result of this combined use of resources was a population explosion in the area, rapid economic growth, the founding of cities such as Port William and Duluth, and Lake Superior's arrival on the world's map. Great predictions were made for the lake's future as a resource base and tourist attraction. Yet each of these industries, from tourism to taconite, has had its toll on the lake.

While tourism is a non-extractive industry (that is, it doesn't rely on taking limited natural resources out of the earth or the forest), it is a mixed bless-

ing for Lake Superior. Second homes and hotel developments continue to take over land that was undeveloped or in the hands of locals such as fishing families.

The greatest ecological threat now faced by Lake Superior is that of atmospheric deposition of toxic substances. This is seen in the lake itself, where more than 90% of some of the toxics in the lake enter the lake from the air. For example, more than 30 kilograms of DDT enter Lake Superior every year from atmospheric sources as far away as South America. It is also seen in the streams that flow into the lake. The highlands along the Minnesota north shore have some of the most acidic precipitation in the state, and the streams that flow into the lake from these highlands carry an "acid pulse" every spring from melting of acidic snow.

RESTORING A HEALTHY BALANCE

Public and private decisions will be right when they tend to preserve the integrity, stability and beauty of the biotic community.
—Aldo Leopold, 1966

Around Lake Superior are seven Areas of Concern (AOCs), pollution "hotspots" identified by the International Joint Commission in 1987 in a protocol attached to the 1978 Great Lakes Water Quality Agreement. These seven sites represent another side of the economic growth experienced around Lake Superior from the 1850s forward. Some are linked to one specific industry. Others are the legacy of many different industries as well as public neglect.

In an effort to maintain the water quality around the Lake Superior region, the International Joint Commission initiated Remedial Action Programs (RAPs) in these seven Lake Superior AOCs: Peninsula Harbor, Jackfish Bay, Nipigon Bay and Thunder Bay, Ontario; St. Louis River/Bay, Minnesota and Wisconsin; Torch Lake and Deer Lake-Carp Creek/River, Michigan. These locations are identified Areas of Concern (AOCs) because of the presence of heavy metals and toxic organics, biological impacts, fish advisories and in-place pollutants. In addition, all but Carp Creek are affected by conventional pollutants and municipal industrial point source pollution. Thunder Bay suffers from beach closings, as well.

The goal of RAPs is to clean up historical pollution problems and prevent future impairments of beneficial uses. This effort requires the involvement of citizens, industry and government in both Canada and the U.S. By restoring the quality of Lake Superior, the entire Great Lakes system is being restored to a more healthy balance of chemistry and biology.

In 1991, following citizen recommendations, Lake Superior was designated by the IJC as the demonstration for zero discharge of persistent toxic substances. Of the five Great Lakes, Lake Superior is by far the most pristine. Recognizing that there really are no acceptable levels of discharge of persistent toxics, the IJC recommended that the governments, industries and citizens around Lake Superior work towards eliminating all sources of these toxics.

Habitat management or restoration projects are in progress in close proximity to all seven of the AOCs. One example is the protection and reconstruction of common tern nesting grounds on Wisconsin and Minnesota Points. Another example is found in the efforts of high school student volunteers working with the St. Louis Riverwatch program. By placing value on the lake and life dependent on it, the citizens and governments of both Canada and the U.S. can work together at all levels.

While there are animals to indicate when the lake is becoming degraded, in the case of Lake Superior, we must remember the citizens around the lake and the other Great Lakes will be affected not long after. The relationship between humans and the lake is so interdependent that its value is immeasurable and cannot be taken for granted. While we need the lake for its thirst-quenching, fish-providing, garden-watering qualities, we also need it for its beauty and magnificence.

Food Chain Tag

Pollution has harmful effects on a food chain—for both humans and animals. Learn the concepts of "bioaccumulation" in this lively activity focusing on relationships between toxic materials and the health of a living system.

TOPIC
Bioaccumulation in food chains.

AUDIENCE
Grades 3-6, 15-30 students

LENGTH
30-40 minutes

GOAL
To see the relationship between toxins released in our environment and toxins found in living organisms.

OBJECTIVES
- *Students will be able to describe, in simple terms, how bioaccumulation works.*

MATERIALS
- *small squares of paper to represent food—see "Getting Ready" (poker chips work well, too)*
- *4 boxes in which to place the food squares; divide the food squares between boxes*
- *Effects of Toxins chart (see page 105)*
- *10-15 small bags, enough for each water flea to have one at the start of game. These can be called "stomachs."*
- *flags to mark three different groups of students, e.g. red flags, yellow flags, no flags. (borrow from the physical ed. person)*
- *bright cones to mark area boundaries*

BACKGROUND

Lake Superior and the rivers that flow into it have harmful chemicals like mercury and PCBs. Mercury comes from rocks and soils. Mercury is also in the smoke that comes from many factories and cars. PCBs are in oil used by industries. PCBs enter the air and water from burning or because the chemicals were not stored safely. These are just two examples of contaminants that are present in Lake Superior and many other lakes, ponds and rivers.

Note the bioaccumulation information in the background section of *The Living Lake Superior.* See also "Great Lake Settlement: Anishinabe" (page 125) in *The Cultural Lake Superior.*

GETTING READY

There need to be at least 5 food squares per student, so 150 squares are needed for a class of 20-30 students, and 100 squares for a group of 15-20 students. Mark 1/3 of the food with an X (on both sides) to represent toxins in the food.

Mark off boundaries outside, in the gym, or in the cafeteria. The field size should be about 25x20 meters. Adjust it as you see fit. Spread the food squares out in this area. If you are outside, make sure your squares don't match the ground or snow color and that they can't blow away.

PROCEDURE

1. Introduction (in the classroom)

Tell the students that they will be playing a game today. It is a game of life or death. Not only may they be eaten, but they may also suffer the effects of toxic poisoning. In this game they will also model a food chain. Briefly explain some of the background information with this lesson. Review with students what food chain means. Show an example on the board if necessary.

2. Set up game (at playing site)

Separate the students into three groups. About 1/2 will be water fleas, 1/3 will be minnows and the remainder will be loons. Hand out the flags or use an alternative identification method. Hand out "stomach" bags to the water fleas.

3. Fleas first

Explain that the water fleas must collect the food tokens and put them into their "stomachs" to survive. Send the fleas into the playing area for 60 seconds to pick up as many pieces of algae as they can.

4. Minnows middle

Send in the minnows. The minnows have 60 seconds to try to catch the water fleas by tagging them and then

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taking their "stomachs." If a water flea is caught, they must give all their food tokens to the minnow and then the dead water flea leaves the field.

5. Loons last

The loons have another 60 seconds to try to catch the minnows in the same way and receive their "stomachs." Meanwhile, the minnows are still trying to get the water fleas. Remind them that they must stay inside the boundaries.

6. Collect results

Stop the game after a few minutes and gather everyone together to find out who survived. Have survivors count the number of toxic food particles they have and compare that number to the toxic chart to see if there are any consequences because of the pollution.

7. Discussion

What does it take to survive in the real world of Lake Superior? (Food, clean water, habitat/space.) Discuss how toxins move up the food chain. This is a problem because organisms need food to survive. Organisms store toxins in their tissues, especially fatty tissues. When they are eaten by another organism those toxins are passed on and become more concentrated. This process is called bioaccumulation. How do we fit into this chain? When we eat contaminated fish we too accumulate toxins.

Which fish do the students think would be more dangerous to eat? (Larger, older fish are more harmful because they have many years of built up accumulation in their bodies. Bottom fish may be harmful because they stir up the bottom soil where many toxins settle. These chemicals move into their bodies as they swim.) Which are less dangerous? Why? What parts of the fish are most harmful? (The fat of the fish contains more toxins that the meat.) If available, have students examine a local fish consumption advisory.

8. Wrap-up (back in the classroom)

Another dimension of survival is what happens when a new, foreign species is introduced into a system. What might happen in this game if a new fish entered the scene, a fish that reproduced rapidly but which other fish wouldn't eat because it was too spiny? Review that all of the organisms in the game needed certain things to survive-food, water, and space. Have the students explain what can happen to make those needs hard to meet. Are there any ways people can help?

ASSESSMENT

Have the students write down an explanation of bioaccumulation, or draw a picture to show bioaccumulation.

REFERENCES

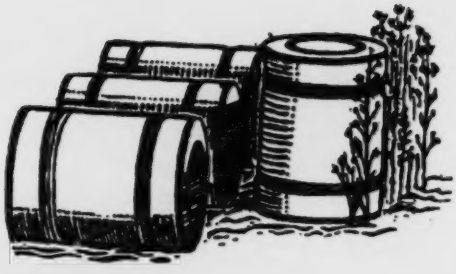
For more information on local fish consumption advisories, write to the following local agencies:

MN FISH CONSUMPTION ADVISORY
Minnesota Dept. of Health
717 Delaware Street S.E., PO Box 9441
Minneapolis, MN 55440-9441

WI FISH CONSUMPTION ADVISORY
Wisconsin Dept. of Natural Resources
PO Box 7921, Madison, WI 53707

MI FISH CONSUMPTION ADVISORY
Michigan Dept. of Public Health
Division of Health Risk Assessment
PO Box 30195, Lansing, MI 48909

ONTARIO FISH CONSUMPTION ADVISORY
Environmental Monitoring and Report Branch
125 Resource Road, Etobicoke, ON M9P 3V6



Effects of Toxins

ANIMAL	NUMBER OF TOXIC PAPERS IN "STOMACH"	STATUS
WATER FLEA	Less than 3	Survives
	3–4	Survives but cannot reproduce
	More than 4	Dies
MINNOWS	Less than 4	Survives
	4–6	Survives but cannot reproduce
	More than 6	Dies
LOONS	Less than 5	Survives
	5–8	Survives but cannot reproduce
	More than 8	Dies

TOPIC
The natural history of the Eurasian ruffe and how people are trying to control its spread.

AUDIENCE
Grades 6-12

LENGTH
1-2 hours

GOAL
To understand the complexity of exotic species issues and the efforts to control them.

OBJECTIVE
- *Students will be able to describe three alternate methods for dealing with the Ruffe.*

MATERIALS
- *Group name signs, folded to stand up on a desk or table:*
  - *Save Our Lake Superior (SOuLS)*
  - *Pictured Rocks National Lakeshore*
  - *Munising Visitors' Bureau*
  - *Grand Marais Sport Anglers*
  - *Friends of the Ruffe*
- *Props for each interest group:*
  - *Tie for Michigan DNR*
  - *Lake Superior t-shirt for SOuLS*
  - *Ranger cap for Pictured Rocks*
  - *Munising t-shirt or cap for Visitors' Bureau*
  - *Fish net for Sport Anglers*
  - *Cap printed with "Save the Ruffe" for Friends*
- *Copies of the problem statement and statements from the DNR and the interest groups*
- *Supply of Ruffe Watch cards for students to keep (optional)*
- *map of Lake Superior*
- *note paper (20 sheets total, or 3-4 for each work group)*

Ruffe Public Hearing

Hold a mock public hearing to plan for the possible invasion of the Ruffe!

BACKGROUND

The ruffe is an exotic species which was introduced to the Duluth/Superior harbor at the western end of Lake Superior in the mid-1980s (read "Problem Statement" on page 108 for more information). It is a real-life problem in Lake Superior. The U.S. Fish and Wildlife Service (USFWS) announced a ruffe control plan in December 1994, which included most of the control methods described in this lesson. USFWS officials are trying to keep the ruffe on the western side of the Keweenaw Peninsula. If the ruffe spreads beyond the Keweenaw, then a new plan will have to be created. There is a fairly good chance that despite the plans and efforts, ruffe will show up in Munising Harbor before 2000.

This activity engages students in a real-life problem, role playing groups which are either real-life or fictional.

GETTING READY

Prepare the problem statements by photocopying the attached sheets and cutting them in half. Set up the classroom to facilitate small group work and a focus on a head table for the DNR.

PROCEDURE

1. Introduction

Explain to students that they are going to participate in a make-believe debate about an exotic species in Lake Superior. Give students basic background information about the ruffe and pass around Ruffe Watch cards for students to look at and keep. Use the map of Lake Superior to show Duluth/Superior, where the ruffe first were found and Munising, where the hearing is supposedly taking place.

Explain that they are a part of this debate just as community members participate in town meetings or open forums. Possibly relate this to some other local issue that the students or their parents may be involved in. Read aloud the "Problem Statement."

2. Getting ready

Break students into six groups. Five of these groups will represent interest groups, and one will be the Michigan Department of Natural Resources (DNR). Place the group name signs on each group's table or area. If possible, have an adult, such as the principal or a parent volunteer, with the DNR group (if more adults are available, have them with each group). Ask each group to study their prepared statements. Each group should then write a proposed plan of action for the DNR, based on the "Proposed action" following their statements but in their own words.

3. Opening statements

Get groups into the spirit by handing out props for each group. Have each group read their statement, starting with the DNR. The other groups

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should read their proposed actions as well. Make sure the groups are speaking clearly. The DNR should take notes on the presentations, as they will be asking questions of each group. Each of the presentations give the specific group's interests and their proposal for dealing with the ruffe.

4. Questions

The DNR will ask one question of each group. Following the DNR's question, other interest groups will have the opportunity to ask a follow-up question of the group questioned by the DNR. Each group may ask only two follow-up questions.

5. DNR—Deliberation and decision

Give the DNR 10-20 minutes in a quiet place or another room to make their decision about how to deal with the ruffe. It really helps to have an adult with the DNR at this time, to guide their decision making process.

When the DNR returns to the room, allow them plenty of time to present their decision. If time allows, the interest groups may ask the DNR about the decision, although the decision itself is final.

6. Wrap-up

Discuss how kids felt about being a member of their interest group. Why is it important to look at all sides of an issue? Discuss with students the connection between the natural community and the human community.

EXTENSIONS

- Have students develop a similar activity with another exotic species, e.g. spiny water flea or the sea lamprey.
- Have students follow up on the activity by writing a letter to Michigan DNR expressing their knowledge and beliefs about the ruffe problem.

ASSESSMENT

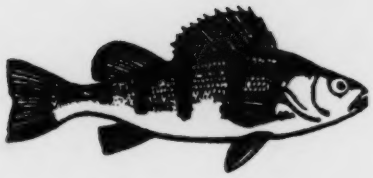
Student presentations throughout the activity will indicate their level of comprehension of the material and the methods.

REFERENCES

A useful Ruffe information booklet, produced by Minnesota Sea Grant, is available through Sea Grant offices around the lake.

Michigan Sea Grant, U.P. Extension Center, (906) 228-4572.

This activity was designed as part of a learning kit project with Pictured Rocks National Lakeshore



Problem Statement

The Eurasian Ruffe is an exotic species that was introduced to the Duluth/Superior harbor in 1987. It is believed to have arrived in the ballast water of an ocean-going ship which came from a port in Europe. An adult ruffe is approximately 5 inches long and weighs up to a pound. The ruffe is closely related to the native perch.

The ruffe quickly established itself in the Duluth/Superior harbor. The warm, shallow water of the harbor was similar to the warm water of its original habitat in Europe.

The ruffe is unlikely to survive in the deep, cold water of Lake Superior itself. It strongly prefers the habitat available in the mouths of rivers that flow into the lake, where the water is warm and shallow. The ruffe has gradually spread eastward from Duluth/Superior along the south shore of Lake Superior. It has been found at the mouth of all major rivers on the Wisconsin shore, and is now found in the Michigan harbor of Ontanagon.

In the Duluth/Superior harbor, the ruffe has had major impacts on the ecology of the harbor. Larger fish don't often prey on the ruffe because of the long spines of its dorsal fin. The ruffe itself also feeds on the eggs of other small fish. Since 1987 the ruffe population has grown to the point that over half of the fish in the Duluth/Superior harbor are ruffe. Local anglers are reporting a significant drop in their catch of predator species such as walleye and northern. Similar effects are predicted for the other locations where ruffe have been found.

There is no existing approved chemical treatment that would be effective at eliminating ruffe while not harming other fish and wildlife populations. The chemical TFM has been used successfully, but it is approved only for lamprey reduction at this point.

The ruffe have no known natural predator in their native European waters.
Aquatic biologists are predicting that without immediate intervention, the ruffe will arrive in Munising harbor in the next year, and in the Grand Marais, Michigan harbor the following year.

The question that Michigan DNR must answer is: What steps should the DNR and the people of Munising take to keep the ruffe from invading the harbor?

Michigan Department of Natural Resources

STATEMENT

Greetings, and welcome to this important public hearing. We are here today to make a plan to deal with the possible invasion of Munising Harbor by the European Ruffe. As a government agency, we must hear every side of the issue before making our decision. Our final decision will be as fair as possible to all people involved.

The Department of Natural Resources will implement whatever plan we develop today.

We are eager to hear your views and ideas on this important topic. The purpose of the first round of the public hearing is to determine what the scope of the problem is. We invite each group represented here to present a short statement of how they believe the ruffe would affect their lives and interests.

Grand Marais Sport Anglers

STATEMENT

We are the Grand Marais Sport Anglers, and we represent over one hundred recreational anglers in the Grand Marais area, including five charter fishing operations. For those of you who do not know, Grand Marais is located forty miles east of Munising, on the other side of Pictured Rocks National Lakeshore.

We love to fish, and for many of us, fishing also provides food and a source of income. We believe that the ruffe would destroy our fishing, since it replaces the natural prey base and is hard for larger fish to catch. Those larger fish are the ones we like to catch. If they can't eat, we can't eat...and neither can our children.

PROPOSED ACTION (PUT IN YOUR OWN WORDS)

- Michigan DNR should find a predator fish which will feed on the ruffe. This would control the ruffe population and provide our anglers with another sport fish to catch.

Save Our Lake Superior (SOuLS)

STATEMENT

Our group, Save Our Lake Superior (SOuLS), believes that we should try to return Lake Superior to the way it was in 1850, before the white people brought their polluting ways to this land. We know we have a long way to go, since much damage has already occurred to this lake. Lake Superior now has many species of fish it never had before, like the sea lamprey and the steelhead.

We hope to keep the ruffe out of Munising harbor, because then we won't have to get rid of it later on. As they say, a stitch in time saves nine.

PROPOSED ACTION (PUT IN YOUR OWN WORDS)

- DNR must inspect all incoming boats for ruffe, and give heavy fines to any boat that has ruffe in it.
- DNR should avoid all use of chemicals.
- Place nets in both channels on either side of Grand Island to create a physical barrier for the ruffe.

Pictured Rocks National Lakeshore

STATEMENT

Pictured Rocks National Lakeshore is a unit of the National Park Service and is located on the shore of Lake Superior between Munising and Grand Marais. Our mission is to protect the natural resource of the Lakeshore while encouraging the public to visit the Lakeshore and experience its many natural wonders.

We believe that the ruffe will endanger our fragile Lake Superior ecosystem. The lakeshore has four major river mouths along its shoreline, and each of these could be a habitat for a small population of ruffe. We believe that teaching people about the damage ruffe can cause will make them want to keep the ruffe out of our area.

PROPOSED ACTION (PUT IN YOUR OWN WORDS)

- DNR should use the Pictured Rocks staff to teach the public about the ecology of the Lake Superior community and the impact of the ruffe, doing programs for park visitors as well as for schools and communities along the shoreline.

Munising Visitor's Bureau

STATEMENT

The Munising Visitor's Bureau believes that tourism is the economic wave of the future for our area. People come from hundreds of miles away to take in the scenic beauty of this area. It is our job to promote the Munising area to tourists and to make sure that they've got lots to do when they get here. Tourism keeps our motels and campgrounds full and our restaurants busy.

If people hear about the ruffe and its impact on the ecology of the Lake, many will choose not to come to Munising. Tourists want to see real nature, not a lake full of exotic species. Tourists that want to fish while they're here would be out of luck if the ruffe takes over.

PROPOSED ACTION (PUT IN YOUR OWN WORDS)

- DNR should use the chemical TFM to treat the streams where ruffe might be found. (TFM gets rid of the lamprey and ruffe).

Friends of the Ruffe

STATEMENT

We are the Friends of the Ruffe. We believe that all animals have the right to exist wherever they can find a habitat. If one animal is stronger than another, we believe that it should be allowed to take over a habitat, if it can.

The ruffe is a smart fish, ideally suited to the habitat found in the harbors of Lake Superior. Yes it is an exotic species, but so are we all. Lake Superior is only ten thousand years old; everything that lives in it had to come from somewhere else. The change that the ruffe would bring to the harbor ecosystem is nothing compared to the damage that humans have caused in the last one hundred years.

PROPOSED ACTION (PUT IN YOUR OWN WORDS)

- DNR should do nothing to stop the ruffe from coming.

Would You Drink This Water?

Use your sense of sight, smell and taste to examine six water samples for "drinkability." Is it possible to make undrinkable water drinkable again?

TOPIC
Water quality.

AUDIENCE
Grades 3-6, 4 to 25 students

LENGTH
20-30 minutes

GOAL
To raise awareness that water is a precious resource and pollution is not always visible.

OBJECTIVES
- *Students will understand that pollutants are often invisible.*
- *Students will name at least one reason we should keep our water clean.*

MATERIALS
- *clear plastic cups (a set of 6 for each group)*
- *water*
- *green food coloring*
- *powdered coffee creamer*
- *peppermint extract*
- *onion extract*
- *salt*
- *blindfolds (separate set of two for each group)*
- *Would You Drink This Water? log*

BACKGROUND

Only 2.8% of earth's water is fresh water. That small bit of water is essential to our survival—so our use of it is a vital issue. The hydrologic cycle teaches us that no new water is made. The water here on earth today has been here for eons and is continually cycling between precipitation, transportation, storage, and evaporation. Water in this system can become polluted from many sources including air emissions, runoff and point source contamination. It can be cleaned by processes of infiltration, but not every type of pollution can be cleaned up. We must be careful to keep water a renewable resource and not pollute it to the extent that drinkable, usable water becomes a scarce commodity.

GETTING READY

Make enough copies of the "Would You Drink This Water" log. Each page has three logs, so copy one page for every three students and then cut the pages into thirds.

Just prior to the event prepare your "polluted" water samples for each group. Fill six glasses 3/4 full of water and label them "1" to "6." Pollute five individual glasses with one of these substances: green food coloring, onion extract, coffee creamer, salt, and peppermint extract. One glass should be left as water only. The plain water, onion, salt, and peppermint extract should appear clear. The food coloring and coffee creamer will be cloudy. Place these six glasses out of sight for use later in the activity. Make sure to use clean, unused blindfolds and sterilized cups for each group.

PROCEDURE

1. What's up?

Explain that the cups represent six different water samples taken from around Lake Superior. The students are scientists who have been asked to examine these samples and decide which are fine to drink. They are to keep track of their findings. Students will use a series of simple tests rather than using their scientific equipment today. As a large group, or in smaller groups of four to five, assign someone to record responses (one for each group), and give them the Would You Drink This Water? log. Next, select two volunteers to be the "samplers" and give each of them a new, clean blindfold (don't reuse blindfolds for additional groups).

2. Try it out

From a distance, let the group(s) visually decide which water they would drink and record it on their log. Now, you should blindfold the volunteers. Explain that the water won't make them sick. One will taste (small sips

only!) and the other will smell the samples. (If doing this activity with more than one group, use a clean glass each time for tasting the substances.) Remind the audience and volunteers to keep their reactions secret until each of them has had a chance to try the liquid, and they are asked to respond by the recorder. Change the order of the glasses so that the blindfolded volunteers won't know which one they are sampling.

3. What happened?

Bring the groups back together. Have them compare the differences between the sight, smell, and taste preferences, and which ones they thought were fit to drink. Share with them the contents in each of the samples and share how these could represent real situations: for example, green food coloring as algae, onion depicting the smell of an oil spill, coffee creamer as turbid water, and the peppermint representing a substance that can be tasted but not seen.

4. Making a difference

Have students brainstorm ways they would go about making their samples all fit to drink. What methods of "clean-up" would they try? (filters, chemicals, etc.). What if these samples contained real contaminants like mercury, PCBs, or raw sewage? Would we be able to see those contaminants? Smell them? Taste them? What could they do to make that water drinkable? How long would it take? Discuss why it is important for us to keep our water clean.

ASSESSMENT

Ask students to imagine a time when most surface water was clean enough to drink without filtering or chemical treatment. Have students write a poem or short essay about the value of clean fresh drinking water.

EXTENSIONS

- Starting with "All the Water in the World" lesson will give students a good background for why this activity is important.
- Have older students research various types of water pollution and how they are treated at water treatment plants. What types of pollution are most difficult to get rid of? What types of pollution are of particular concern in Lake Superior? Which cities and towns get their drinking water from Lake Superior?
- As a follow-up activity have the students bring in materials or find material to use in making a filter system for their samples. Make up a batch or find a batch of polluted or dirty water that seems particularly bad. Have students test their filters on it.
- Take a field trip to a water treatment plant to see how cities clean their water and to talk to experts about local water issues.

REFERENCES

Adapted from "Would You Drink This Water?" in MinnAqua's *Fishing... Get in the Habitat.*

Would You Drink This Water?

Which glass of water would you drink based on your senses of sight, smell, and taste? Place an "X" in each column if you would drink this water sample.

	Sight	Smell	Taste
Glass 1	_____	_____	_____
Glass 2	_____	_____	_____
Glass 3	_____	_____	_____
Glass 4	_____	_____	_____
Glass 5	_____	_____	_____
Glass 6	_____	_____	_____

Would You Drink This Water?

Which glass of water would you drink based on your senses of sight, smell, and taste? Place an "X" in each column if you would drink this water sample.

	Sight	Smell	Taste
Glass 1	_____	_____	_____
Glass 2	_____	_____	_____
Glass 3	_____	_____	_____
Glass 4	_____	_____	_____
Glass 5	_____	_____	_____
Glass 6	_____	_____	_____

Would You Drink This Water?

Which glass of water would you drink based on your senses of sight, smell, and taste? Place an "X" in each column if you would drink this water sample

	Sight	Smell	Taste
Glass 1	_____	_____	_____
Glass 2	_____	_____	_____
Glass 3	_____	_____	_____
Glass 4	_____	_____	_____
Glass 5	_____	_____	_____
Glass 6	_____	_____	_____

A Lake Superior Raindrop Journey

Participate in story-telling about weather, pollution, run-off and Lake Superior water quality—learning a simple tale of bioaccumulation.

TOPIC
Airborne pollutants and how they enter Lake Superior and its food chain.

AUDIENCE
Grades K-4, 12-30 students

LENGTH
20 minutes

GOAL
To increase understanding of how airborne pollutants work their way into the Lake Superior system and how they can affect people.

OBJECTIVES
- *Students will participate in a creative demonstration of the interaction between weather, pollution, run-off and the water quality of Lake Superior.*
- *Students will be able to describe the pathways of pollution as depicted in the story (i.e. via rain, via soil).*

MATERIALS
- *script for teacher*

PROCEDURE

1. Introduction

Explain that students are going to be actors in a play. Depending on the size of the class, have two to five students represent each of the six characters. Assign each group of students a part and then ask them to practice (or make up) their sound/action.

Angler—*"Yee Haw!"*

Fish—Pucker the lips

Clouds—Like the wind, *"wsshhhhh..."*

Raindrops—*"Bloop...bloop...bloop..."*

Pollution Molecules—Ominous, dark, and deep; *"boom-boom..."*

Soil—*"Squish... squish..."*

2. Action

Read the story (on the next page), and whenever the character's name is used, those students must give the appropriate sound or motion effect.

3. Wrap-up

Discuss with students what they learned from the story.

ASSESSMENT

Have the students draw the route pollution has taken from the atmosphere to the angler!

EXTENSIONS

- Have the students dictate or write "Chapter Two" to this story. Have the next chapter be about pollution entering Lake Superior from a different source, perhaps overflow from a water treatment plant, pollution carried in rivers, or septic system leakage.

A Lake Superior Raindrop Journey

Once upon a time a bunch of water molecules had formed together to become a *cloud*. They were very happy there, being moist and having lots of friends about. But eventually the *clouds* became so crowded with water molecules that they could not hold together! "We're full. We can't hold together anymore," said the water...and with that, the cloud broke a part and the water drops were free.

Now the water molecules are *raindrops* and they separate from the *clouds* and move towards earth and Lake Superior. On the way, they see some *pollution molecules* hanging in the air waiting for a ride. The *raindrops* try to avoid the *pollution*, but they are spotted and approached. "Can we catch a ride with you down to earth?" the *pollution* asks the *raindrops*.

"No way," say the *raindrops*, "you're poison. You stay up here!"

"Forget it! You have no choice, we're coming with you!" exclaim the *pollution molecules*. And so the *pollution molecules* attach themselves to the *raindrops*.

So the *raindrops* continue on their journey to the planet earth, each now with a *pollution molecule* attached to them. When they get to earth, some go directly into Lake Superior and become part of the lake water. They mingle in the water with the plants and smallest water animals. The plants and small critters don't even realize that the pollution is now a part of them. Then the *pollution*, which is inside of plants and small animals, sees the *fish*, and says, "Ooh, I want to come and live in you."

The *fish* responds, "No chance. You're poisonous and I don't want to be near you."

But the *fish* doesn't realize that the *pollution molecule* is already in its food! So the *fish* ends up eating it!

"Oh, no," sighs *fish*, and sickly swims away.

Meanwhile, the rest of the *raindrops* fell onto the land. They're trying to get into the lake by going through the *soil*. As they move through the *soil*, the *soil* grabs onto the *pollution molecule*.

"Hey, what's the big idea?"asks the *pollution*.

"I'm sorry, but you'll have to stay here. See, we're *soil*, and one of our jobs is to prevent poisonous things like you from getting into the lake."

"But I just saw my other friends, and they are already in the lake and that's where I want to go," replied the *pollution*.

"Like we said, you won't be making it there this time around," the *soil* answers.

"Oh, man! I can't believe it!" *pollution* says. So the pollution pieces all separate from the *raindrops* and stay in the *soil.* The clean *raindrops* work their way into Lake Superior.

Enter the *angler.* "Alright," she says, "time for me to catch some dinner." She casts out and reels in one of the *fish* that now has *pollution* in it. "It's a whopper!" she exclaims as she lands the *fish.* "I can't wait to fry this up and sink my teeth into it." She cooks it and then takes a bite. "Mmmmm, this is good," she says, and finishes the whole *fish.* But then she says, "You know, I suddenly don't feel very well." The *angler* may not know right away why she feels poorly, but you and I know the *fish* had toxins in it that can accumulate and make people ill! Unless that *pollution* is removed, the *angler* may not be able to eat fish anymore.

THE END.

A Lake Like No Other

Why is Lake Superior so special? Learn about its vast size and uncrowded shores through role playing of both people and pollution.

TOPIC
Population density and pollution.

AUDIENCE
Grades 5-12, 20-40 students

LENGTH
30 minutes

GOAL
To see how population density and lake volume impact Great Lakes water quality.

OBJECTIVES
- *Students will understand that the majority of people living in the Great Lakes Basin live on the US side of the international border.*
- *Students will understand that Lake Superior has the lowest population density of any of the Great Lakes.*
- *Students will connect the relative pollution concentration with the population.*

MATERIALS
- *Great Lakes Data Chart (from Appendix)*
- *Population chart*
- *5 strings which are proportional circumference representations of each of the Great Lakes (see below)*
- *wadded-up paper with names of various types of pollution printed on them*

BACKGROUND

Lake Superior is very different than the other Great Lakes when you look at the size of the lakes and compare to the population within their basins. Compared to the other lakes, Superior is huge and unpopulated. This lack of people and industrial development is one of the primary reasons the water quality remains as good as it is.

GETTING READY

Cut five lengths of string to represent the proportional surface area of the Great Lakes. The following lengths in meters are provided for groups of less than 30 (lengths in perentheses are for groups greater than 30):

Lake Superior	8.5 (11.0) m
Lake Michigan	6.0 (7.5) m
Lake Huron	6.0 (7.5) m
Lake Erie	2.5 (3.0) m
Lake Ontario	2.0 (2.5) m

Establish an international border on the floor with a strip of tape. Arrange the loops of string that represent the five Great Lakes along the border from left to right. Use the diagram below.

Using Chart #1, determine how many students will be "populating" each of the Great Lakes based on group size.

PROCEDURE

1. Introduction

Ask the students to look over the list of facts on the Great Lakes Data Chart. Ask questions such as:

- Which lake has the largest volume? Which lake has smallest?
- Which lake has the largest surface area? Which has the smallest?
- Which lake has the largest population? Which has the smallest?

DIAGRAM

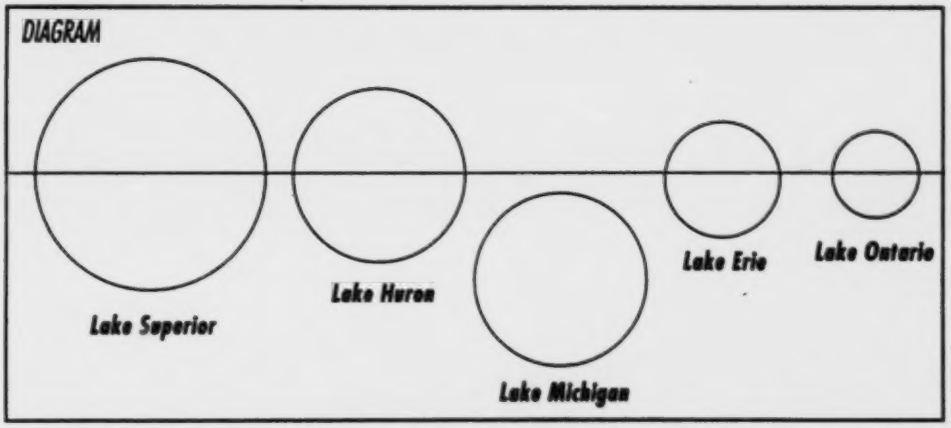


CHART #1

NUMBER OF PEOPLE U.S./CANADA

Total participants	15	20	25	30	35	40	45	50
Lake Superior	0/0	0/0	0/0	1/0	1/0	1/0	1/0	1/0
Lake Huron	1/0	1/1	1/1	1/1	1/1	2/1	2/1	2/1
Lake Ontario	1/2	1/3	2/3	2/4	2/4	2/5	3/5	3/6
Lake Erie	4/1	5/1	8/1	8/2	11/2	12/2	13/3	15/3
Lake Michigan	6/0	7/0	9/0	11/0	13/0	15/0	17/0	19/0

- Do more people live on the Canadian or on the U.S. side of the border?

2. Populate the lakes

Explain that the whole group of students represent all the people living in the Great Lakes basin, and that each student represents between 500,000 and two million people. Have the students fill in the lakes with what they consider to be the appropriate distribution of people, based on the charts and the number of students in the class.

Use the numbers from the chart above to correct the students if necessary. What were their preconceptions?

3. Analysis

Have the students tell what they see. Which lakes are more crowded? Where might the biggest Great Lakes cities be located? (Do maps confirm the responses?)

4. What do all the people do?

Ask the students what impacts people have on the lakes. Some of their responses will involve waste or pollution. When students bring up pollution, step in with the wadded up paper representing some actual types of pollution and their proportions. One type is PCBs—throw one piece each into Superior, Huron, and Michigan, 4 each into Erie and Ontario. Do the same with DDT and lead according to Chart #2 below:

CHART #2

	Superior	Huron	Michigan	Erie	Ontario
PCBs	1	1	1	4	4
DDT	2	1	2	5	2
Lead	1	3	2	3	2

CHART SOURCE: First Progress Report under the 1994 Canada-Ontario Agreement respecting the Great Lakes Basin Ecosystem.

5. Where does it come from?

As students look at the lakes have them guess where the pollution comes from. As it turns out, most of the pollutants in lakes Superior, Huron, and Michigan come from nonpoint sources like air, rain, and snow. Most of Erie's and Ontario's pollution comes from point sources around each lake (sources like landfills, industries, manufacturing plants, run-off from farms and streets, etc.). Talk about how large surface area makes a lake more vulnerable to pollution from the atmosphere (Lake Superior) and large cities around a lake with little volume can cause more direct pollution (Lake Erie).

ASSESSMENT

Ask the students how Lake Superior is unique in terms of population versus surface area.

EXTENSIONS

- Discuss what has already been done to help combat pollution.

  – DDT has been banned in the U.S. and Canada.

  – Leaded gasolines are being used less and less.

  – The importation or manufacture of any PCB-filled equipment in the U.S. and Canada is prohibited.

  – The U.S. and Canada work together on pollution and water issues; an example is the U.S./Canada International Joint Commission and its program to use Lake Superior as a demonstration zone for zero discharge of persistent toxic substances.

- What can you do personally?

Adapted from "How Big is a Crowd?" in Paddle-to-the-Sea Supplemental Curriculum Activities.

Lake Superior Poem

As a group, either small or large, students will brainstorm a list of descriptive words or phrases about Lake Superior. They will then form these words into a structured poem.

TOPIC
A group poem to express feelings about, and impressions of, Lake Superior.

AUDIENCE
Grades 4-8, 3-30 students

LENGTH
30 minutes

GOAL
To build an appreciation for the variety of ways which people perceive Lake Superior.

OBJECTIVE
- *Students will work cooperatively to develop a poem about Lake Superior.*

MATERIALS
- *chalkboard and chalk*

BACKGROUND

All of the students have had contact with Lake Superior in some way. They may swim or fish in the lake, observe the lake in their daily acitivities or learn about the lake through school, books, the media or friends and family. Through those experiences and others, every one of us has impressions of Lake Superior. In this activity students will be using that background.

PROCEDURE

1. Introduction

Explain that the students as a group will write a poem. It is a very structured poem, so the creativity and beauty in it must come from the words. The first and last lines of the poem will be "Lake Superior." The second line will be three verbs that end in "-ing." Give examples such as "running, talking, flying." The third line is three adjectives (descriptive words) that describe the lake, and the fourth line is a phrase or sentence about the lake. Write this format on the chalkboard:

- "Lake Superior"
- 3 verbs that end in "ing"
- 3 adjectives
- phrase or sentence
- "Lake Superior"

2. Brainstorming

Explain that the first step will be to brainstorm a list for each of the three categories. The class will then vote on the top three words for the "-ing" verbs, the adjectives and for the top phrase. Remind students before they brainstorm that this is not the time to judge the words. It's the time to get a good list on the board, and any words that fit the topic are useful. Have them brainstorm the three lists, one at a time, while you write their words on the board.

3. Which words?

When the lists are done, start voting on the words and phrases. Emphasize the students should choose words that sound good; words that describe Lake Superior and their impressions of it well.

4. Write the poem

Write the poem with the chosen words on the board and have students rearrange the order of the words in lines 2 and 3 if they would like. Read it out loud all together.

5. Reflect

Ask the students what they think about the creation. If they did it over again, but individually, what would they do differently? Would they stress a different aspect of Lake Superior next

time? How do they think the poem would change if it were about an inland lake?

ASSESSMENT

The finished poem should match the format set for it.

EXTENSIONS

- Have several students volunteer to copy the poem onto a nice piece of paper and illustrate it. Hang it in the hall so other students can appreciate it.
- Students can create their own individual poems about Lake Superior or a topic that relates to Lake Superior. If their topic is gulls, the first and last lines of the poem should be "gulls." For example:

gulls
soaring, gliding, swooping
bold, white, loud
masters of the lake sky
gulls

Lake Superior Geography Concentration

How much do you know about Lake Superior geography? Based on the child's game of Concentration, students try to find matches of landmarks around the lake as they learn what is where.

TOPIC
Geography and landmarks of Lake Superior.

AUDIENCE
Grades 3-12, 10-30 students

LENGTH
20-30 minutes

GOAL
To appreciate the variety and similarities of Lake Superior geography.

OBJECTIVES
- *Students will learn at least three different Lake Superior landmarks.*
- *Students will identify another Lake Superior community similar to their own.*

MATERIALS
- *large floor map of Lake Superior (see Appendix)*
- *Concentration cards (described below in Getting Ready)*
- *Lake Superior Geography site map (see page 125)*

BACKGROUND

The Lake Superior watershed is large enough to include a wide variety of geographic landmarks, including natural features, cities, and protected areas. In fact, for most of these items, there are two of a kind. The typical residents of Lake Superior have more in common with their neighbors around the lake than with other people in their state or province who live away from the lake. Understanding our place in the Lake Superior community helps link us to the whole lake, both its natural places and the people who live there.

GETTING READY

Prepare the concentration cards (see diagram next page) by printing the names of 12-15 pairs of Lake Superior geographic landmarks on one side of heavy cards (large index cards work great). The included list of Lake Superior pairs works well, but feel free to add your own. If your community or landmark, or a landmark your students identify with, is not on the list, add it along with a pair.

For grades 3-4, in addition to the category name, draw a picture on the cards. Also, reduce the number of pairs to 6 or 8.

Before running the activity, roll out the floor map in an open area and place the cards face down in their proper locations on the map.

PROCEDURE

1. Introduction

Gather students around the Lake Superior map. Ask students if they have ever played "Concentration" (or "the memory game"). Explain that this game runs the same way. All around the lake are matching pairs of geographic landmarks. The match comes from the fact that there are two representatives of categories of landmarks, like "Big City." As part of the explanation, have one student turn over a card and read it. Explain that there is another card with the same category, but with a different location name, in its proper place on the map somewhere.

2. Play it!

Go around the circle of students and have them take turns trying to find

CONCENTRATION CARDS

Write the cards as follows: Category on top, Name below (for example, "Big City: Thunder Bay")

Category	Card One	Card Two
Big city	Duluth	Thunder Bay
Medium city with mining industry	Calumet	Marathon
Medium city with paper industry	Munising	Terrace Bay
Towns named Grand Marais	Grand Marais, Michigan	Grand Marais, Minnesota
Deep spot in lake	Caribou Basin (1330 feet)	North Shore Trench (800 feet)
National Lakeshore	Apostle Islands	Pictured Rocks
Provincial Park	Sleeping Giant	Lake Superior
Wilderness National Park	Isle Royale	Pukaskwa
Historic National Park	Keweenaw	Grand Portage
Canadian island	Slates	Michipicoten
International Border	St. Mary's River	Pigeon River
Large River	Nipigon	St. Louis
State Park	Big Bay	Gooseberry
Native settlement	Pays Plat	Bad River

matches. If a student is successful in finding a match, leave the cards facing up (and on the map) and the student can try again. If the student is unsuccessful, both cards must be turned back over again.

Provide commentary as the game progresses, with background information on the landmarks. Some things to point out are:

- Grand Marais means "big wet area" and was used by the French explorers to describe the fine natural harbors found in these areas.
- Provincial parks are only found on the Ontario shore, because Ontario is the only "province" on the lake.
- Isle Royale and Pukaskwa were both designated national parks by their governments primarily for their wilderness value.
- Keweenaw and Grand Portage (actually a national monument) were created for their historical value.
- In Canada, native settlements are called "first nation reserves." In the U.S, they're called "reservations."

Play the game until all the matches have been found.

3. Closure

Talk with students about the idea of a Lake Superior community. If they live on Lake Superior, ask them to think about what the other town like theirs looks like or feels like (maybe one of them has been there?). What do they have in common with other people who live on Lake Superior?

ASSESSMENT

Students should be able successfully to find all the matches. Let them turn the cards over and try again (maybe the next day), to see how they've learned.

EXTENSIONS

- Have the students write letters to students in their partner community (ask Lake Superior Center for a contact if you don't have one).
- Have students research other pairs on the lake and run the game for another class.

Lake Superior Geography

Great Lake Settlement: Anishinabe

TOPIC
Anishinabe settlement in the Lake Superior region.

AUDIENCE
Grades 4-12, 15-30 students

LENGTH
Two 60-minute sessions (more time may be needed by students to prepare their presentations and to research topics).

GOAL
To gain insight into historical movement of people into and around the Lake Superior region.

OBJECTIVES
- *Students will be able to name at least three essential elements of a village location for the Anishinabe.*
- *Students will be able to name four cultural activities of pre-European Anishinabe.*

MATERIALS
- *Map Cards (page 129)*
- *Topic Cards (page 130)*
- *Life in... Worksheet (page 131)*
- *set of overhead transparencies from maps 1-5 (page 132-136)*
- *photocopies of student maps 1-5 (page 132-136)*
- *Lake Superior map overhead transparency (from Appendix)*

Explore the Native American settlement history of the Lake Superior watershed. Decide where to place your Anishinabe/Ojibwe village using a series of informative maps, then compare your choices with those actually made by the Anishinabe.

BACKGROUND

See background information on "The First Americans" in *The Cultural Lake Superior.*

GETTING READY

Prepare overheads, student maps, map cards, topic cards and the "Life in..." handout from the materials included with this lesson.

PROCEDURE

PART A: WHAT COULD HAVE BEEN

1. Introduction

Have students get into groups of 3-4. They will be in these groups for the entire activity. Instruct students that their small group is now a small village of about 20 people. They are living about 300 years ago at a time in which transportation was either by boat or foot. They must use the resources of their environment for survival. The group has recently been pushed from their homeland by other groups of people. They are not at war. At the point of this activity, they have just arrived at the edge of a large lake. It is up to the people of the village to choose a site on which to live. (As a teacher, know that there are no rules stating that a village must stay in one place year-round. When students write up their village plans they may have questions about this.)

2. Mapmaking

Hand out Map 1 and Map Card 1. Allow the groups time to process the information and place their villages. Hand out each subsequent map and map card giving the groups time to process the data and choose new sites between cards.

3. Presentations

When the final village site choice has been made, have each group come up to the overhead and show where they placed their village. Use a different color for each group's site. Have them give a summary of their reasons for choosing the site, record their reasons on a large piece of paper or a spot you can save on the board.

4. Lifestyles

Now that the site has been chosen, have the students fill out the outline of their village lifestyle, using the "Life in..." worksheet. Groups should be

discussing how to build shelters from the available resources, what to eat throughout the year, how duties will be divided, how to get items they don't have in their region, what they will do for entertainment, whether they will mingle with other villages and how they will get clothing. Encourage all types of discussions that relate to village life; even discussions about such things as waste disposal would be appropriate. If trade comes up and students begin to come to you with questions, encourage them to think of something they have to trade and to talk to other groups that have also asked you about trade.

5. Sharing

Have students share their village outline with other students accompanied by a picture, special trade item they will produce, group history story (a mythical or factual story about how they came to be and how they came to their new home), or a picture story of their group's migration. Students may have come up with many other ways to share their village. They may also want to name their village.

PART B: THE REAL STORY

1. Review

Review the process of lesson one. Put up the final site map with each group's village location and the list of reasons for choosing the sites.

2. Compare with Lake Superior

Although the mystery map didn't represent any real lake, it shared some characteristics of Lake Superior about 300 years ago when the Anishinabe were pushed gradually westward from the eastern Great Lakes region. Our map activity was a very basic way of looking at the choices made by these people. Put up a map of Lake Superior. Point out several historical Anishinabe settlements such as La Pointe on Madeline Island, Wisconsin; Grand Portage and Fond du Lac, Minnesota; and Sault Ste. Marie, Ontario. As a large group make a list of why the Anishinabe may have chosen these sites. Compare it to the list of why the classroom groups chose their sites.

3. Further research

Have students get back into their village groups. Each group will research one aspect of Anishinabe life and present it to the class. Pass out the Topic Cards and give students access to resources on Anishinabe history. Have groups then present their findings to the class in a creative way. What did Lake Superior provide historically for the Anishinabe? What is it providing for the current Anishinabe and all other residents of the watershed? How do our lifestyles today differ from the people who lived 100 years or more in the past? What is the impact of our current collective lifestyle on the lake? After researching these topics, ask the students to go back and make revisions on the list of reasons created in Part A (why do you think the Anishinabe may have chosen these sites?).

ASSESSMENT

Oberve as students present an outline of their village's way of life and give at least three reasons for choosing their village site. Also, observe as students research one aspect of historical or current Anishinabe life and assist their group in presenting the findings in a creative way.

EXTENSIONS

- Have students research Anishinabe treaties in the Lake Superior region. What do the treaties say, what were the attitudes of the times and how are treaties honored today? Look also at reservations /reserves of the Anishinabe. How was their placement chosen? How did those choices affect the people?
- Look at current cities and towns around Lake Superior. Why were they placed where they are. What criteria were used to choose their locations? Where are the newest parts of these cities and towns? How are our criteria changing and what will we look for in the future?
- Hand out the same map to each group of students. Any good map of an area no larger than 100 square miles will do. Assign each group a different historical period. First, they will choose where to place their town of 100 people. Then, they must argue for their town site choice based on their historical point of view. For example, a group in the 1600's may choose a town site along a major river, but a group in the year 1996 may choose to build their to town next to a freeway. Students could come up with some interesting criteria for town placement in the year 2100. Telecommuting may play a role, fuel consumption may be an issue, or perhaps students think the towns biggest concern will be access to clean freshwater?
- Research the settlements of Europeans in the Lake Superior region. What types of criteria did they use when deciding where to settle? How are the criteria similar or different from the Anishinabe criteria?

REFERENCES

Use of maps adapted from a lesson presented by Roger Johnson, University of Minnesota College of Education

Map Cards

Map 1

You are a group of 20 people. Recently being pushed from your homeland by other people, you have just entered this region. It is a time before motors, engines, and mass communication—about 300 years ago. As a group, you possess the knowledge to make small boats, to gather food and building materials, to hunt, and to fish. It is easy to move your village because you traditionally build simple, partially portable shelters and have few possessions to haul with you. Place your village somewhere on the map and label it #1.

Map 2

As you travel you are becoming better acquainted with the lake area. You are constantly discovering new things. Using the new information about waterways on Map 2, decide if you would like to move your village. What reasons might you have for moving? Show the new location of your village if you chose one and label it #2. Write your reasons for moving beside village choice #2 on your map.

Map 3

The terrain of your area is now known to you. Does this work well with your present location? Move your village if you would like. Label its new location #3 and write your reasons for moving next to it.

Map 4

As the seasons go by you have noticed some weather patterns and have observed the flow of the rivers and streams. Use this new information to decide if you would like to move again. Remember that you use small boats or walking for much of your transportation. Move your village if you would like. Label its new location #4 and write your reasons for moving next to it.

Map 5

Much of your existence is based on gathering materials for making shelter and tools, gathering plants for food, hunting for food and clothing, and fishing. This new information greatly increases your knowledge of where your resources can be found. Although the key shows major forest types and lists many tree varieties in that forest type, not all varieties of trees and plants are listed. Do your best with the information provided. Move your village if you would like. Label its new location #5 and write your reasons for moving next to it.

Topic Cards

Anishinabe winter storytelling	***Anishinabe family life***
Anishinabe fishing	***Anishinabe use of resources***
Anishinabe trade	***Anishinabe medicines and gathering***
Anishinabe religion	***Anishinabe treaties and reservations/reserves***
Anishinabe history and movement	***the Anishinabe today***

Life in....Worksheet

1. What type of shelters will you use?
Describe how they will be built and what materials you will use.

2. What will you eat throughout the year?

WINTER:

SPRING:

SUMMER:

AUTUMN:

3. How will you obtain your food and clothing? Be specific.

4. How will your duties be divided?

5. Estimate the amount of time you will spend each day obtaining food, shelter, and clothing.
List each activity and the amount of time you think you will spend on it.

6. What types of things will you do in your spare time?

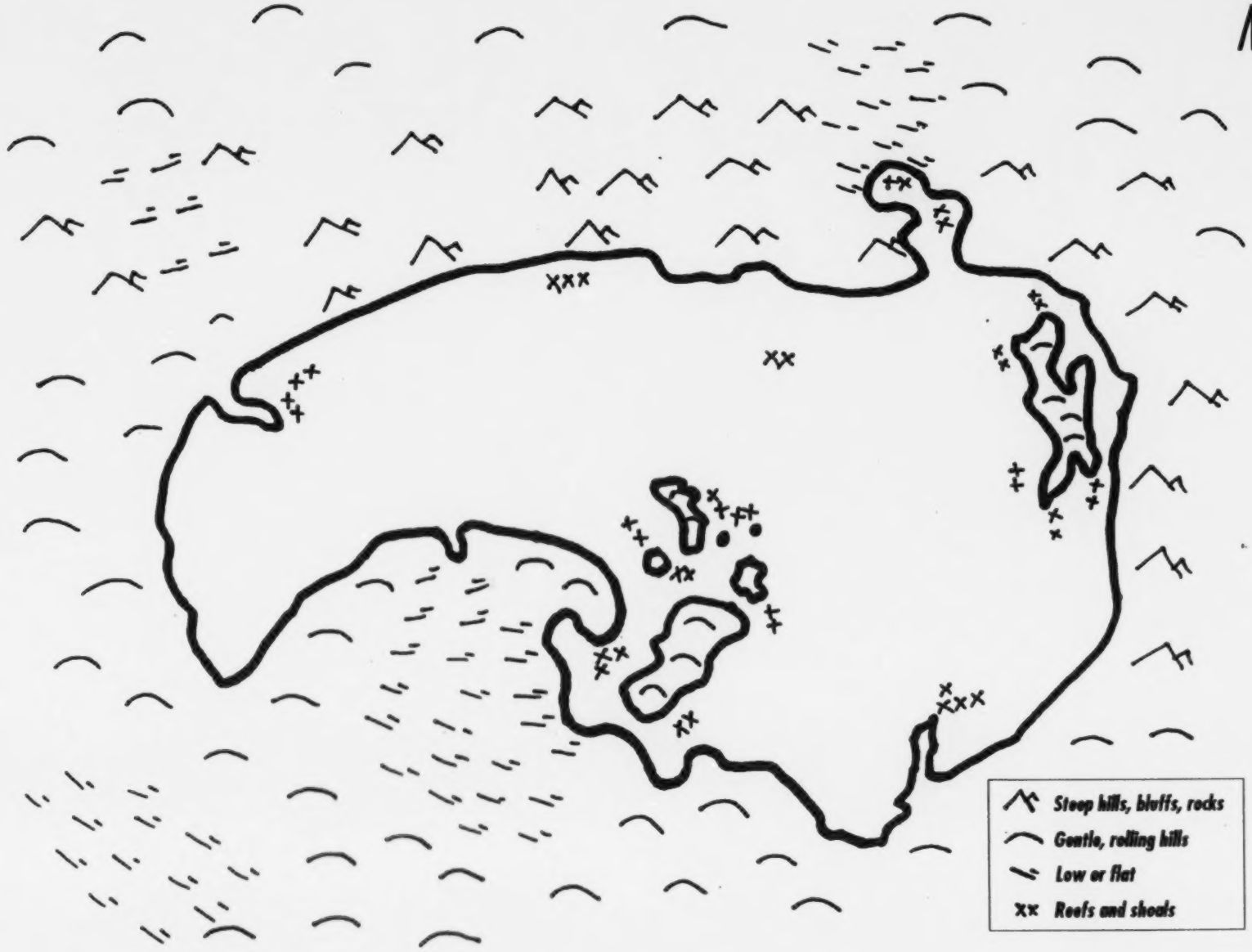
7. How will you obtain items you don't have in your region?

8. What else? Describe any parts of your village life which you haven't already described.
Draw pictures if they would help.

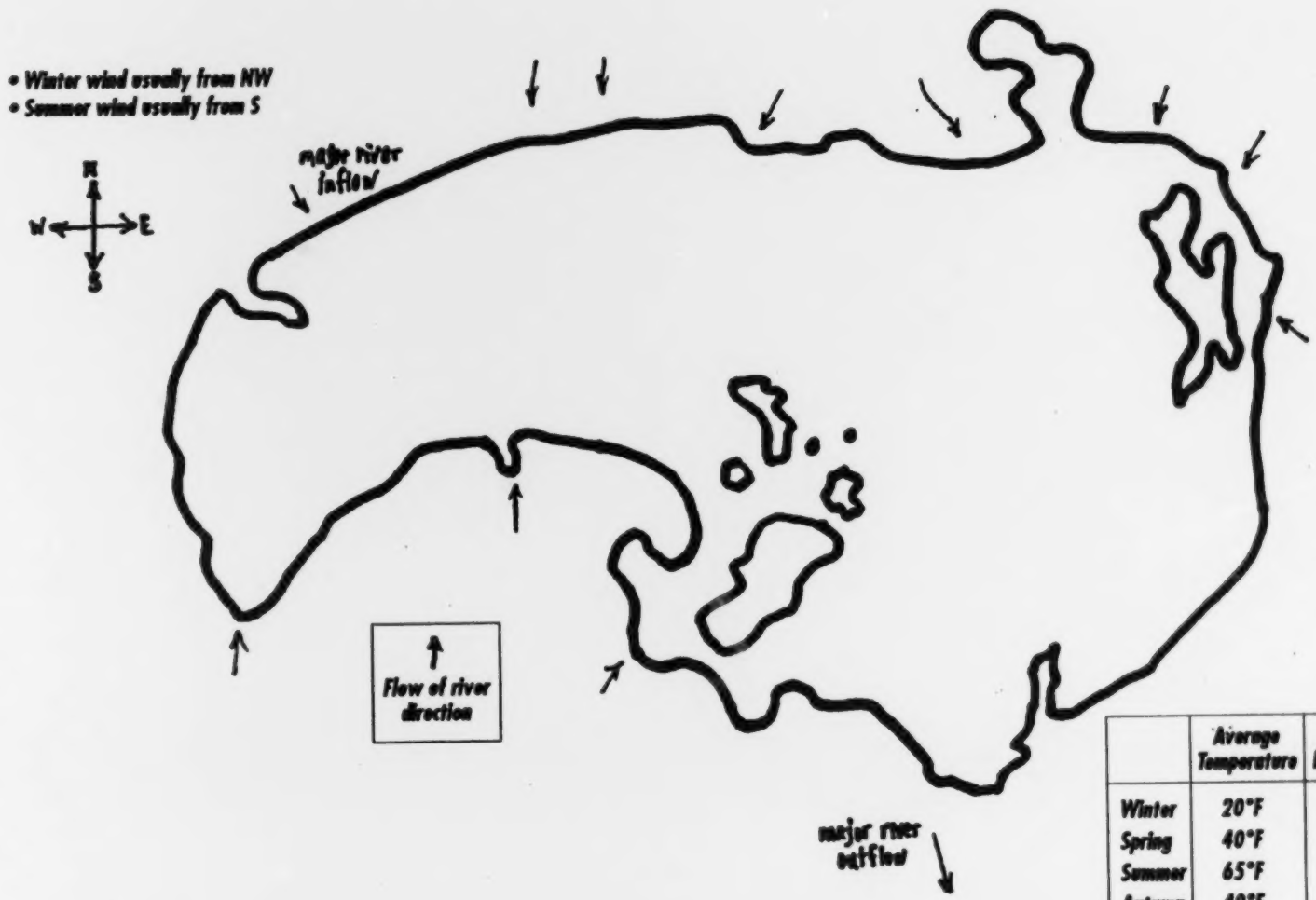
Map 1

Map 2

Map 3


Steep hills, bluffs, rocks
Gentle, rolling hills
Low or flat
Reefs and shoals

Map 4



	Average Temperature	Average Precipitation
Winter	20°F	60" snow
Spring	40°F	15" rain
Summer	65°F	10" rain
Autumn	40°F	10" rain

Map 5

PRIMARILY HARDWOODS
Sugar maple, Yellow birch, Basswood, White pine
PRIMARILY CONIFERS
White pine, Red pine, Paper birch, Aspen, Balsam fir, White spruce
WETLAND
Wild rice, Rushes, Sedges
(1"=20 mi.)
0
10mi.
20mi.
40mi.

Voyageurs—Introducing Me!

An exciting culmination to your classroom study of voyageur history on Lake Superior, as the students create their own fictitious characters and celebrate like the voyaguers did! (well, not exactly...)

TOPIC
Lake Superior and the voyageurs in language arts and beyond.

AUDIENCE
Grades 4-8, 15-30 students

LENGTH
multiple class periods and time in the library

GOAL
To gain insight into the rich history of the voyageurs on Lake Superior, and appreciate the influences they left on the culture of the area.

OBJECTIVES
- *Students will create a fictitious historical character from their background knowledge of voyageur history.*
- *Students will write a story from the life history of their character.*

MATERIALS
- *library or collection of resources on voyageur history*
- *classroom set of a historical fiction novel*

BACKGROUND

See the background information on "Explorers, Traders and Voyageurs" in *The Cultural Lake Superior* (page 96).

PROCEDURE
PART A: CHARACTER RESEARCH

1. Introduction

During your unit of study on the voyageur, focus also on historical fiction in language arts. As your class reads the a chosen work of historical fiction, look carefully at how the author created the characters, what makes the characters dynamic and real and what kind of research was necessary to create the characters. If the author is living, your class could write to her/him and ask questions about character development. Explore author biographies or autobiographies for both living and non-living authors. Ask students to describe the characteristics of historical fiction and what makes it different from historical non-fiction.

2. Character creation

Begin the character creation activity by having students outline the type of character they would like to create, drawing from their study of voyageur history. It should be a character from the voyageur era, should relate to voyageurs, but does not need to be a voyageur (It could someone like a company partner, clerk, Anishinabe trapper, wife of an owner, etc.). Have them use their imaginations to come up with a wide variety of character choices. Next, students make a list of the character's job, personal qualities and history. Name the character and sketch a web out from that character to other people and places and to the character's relationships to them. Students should be given enough background information that they can make a somewhat knowledgeable decision about what role their character might have played in the fur trade. Be sure the students are drawing from real voyageur history and using events and places that fit into that real history. Be ready with beaver research materials for the student who will inevitably ask to be a beaver!

3. Who was I?

Students decide when their characters lived and begin to research their roles and the time period during which they lived. Next, have the students formalize their thoughts by making a list of the following information as an introduction to their character (see student assignment outline sheet):

BEST COPY AVAILABLE

A. Name
B. Birthdate
C. Nationality
D. Occupation(s)
E. Marital Status
F. Mother's Name
G. Father's Name
H. Other Family Information
I. Residence

Next, have students create a personal history by describing 10 highlights of their life including birth and death. These can be short and to the point such as: "born on March 20, 1756," or "I immigrate to Canada and almost die of Scarlet Fever on the way across from France." Stress accuracy of dates and types of events for the time period.

4. How did I live?

Have students describe the way their character would spend an average day. They should incorporate specific knowledge of history whenever possible (see student assignment outline sheet). Students now choose one of the 10 created events to describe in detail. Facilitate the activity by encouraging the students to enrich the story of this event with dialogue and vivid details of that historical period. Examine historical fiction writings by professional authors for how their events are made real and exciting. This is the opportunity for students to really enter the mind of their character and write from that point of view (see student assignment outline sheet).

5. Pulling it together

Students can now put together a packet on their character including the introduction, 10 life events list and the detailed story of one event. Pictures of the characters would make a nice cover to the booklet. Have the students also include a bibliography, accurately citing their sources (see student assignment outline sheet).

On the due date for the booklet, organize a rendezvous day as an exciting culmination to the character creations. Students should come dressed as their character that day, and should be ready to act the part. Following are ideas of things to do that day.

PART B: RENDEZVOUS DAY

GETTING READY

Set up stations at which students can participate in a variety of activities. There are three games and one cooking activity. Students could be in three groups and rotate through the games, then all come together for the cooking. They should come to school this day dressed as their character and be ready to play the part. The following is a list of some activities that could be used at the stations. Older students, parents, or other teachers could be used at each station to facilitate the activities.

"Shoot the Rapids" group initiative

MATERIALS

- 25 carpet squares or squares marked out on a tarp
- 20 cards marked "water" and 20 cards marked "rock"
- several master diagrams showing how to set up the routes

PROCEDURE

This activity works best with about 10 students.

1. Set up

Set up the route with carpet squares arranged in a 5 by 5 square. Lay the "rock" and "water" cards upside down on the squares according to the master diagram. Create your own diagrams and vary the difficulty levels.

SAMPLE MASTER DIAGRAM
X = "ROCK" BLANK = "WATER"

X	X	X		X
X				X
X		X	X	X
X				X
X	X	X		X

2. The rules

Explain to the students that Voyageurs had many hardships to face together. One of those hardships was maneuvering through rapids. The grid on the floor represents a set of rapids which they cannot portage around because the terrain is too rough.

Each student represents one canoe in the brigade. Because each canoe is carrying one element of survival for the group (i.e. flint, steel, food, warm clothes, guide, etc.) either the whole group makes it or they all fail in their attempts. As they approach the rapids, they should know that each fragile birch bark canoe can only hit a rock once.

They will know they have hit a rock when they step on a square, turn over the card on the square and the card says "rock" instead of "water." When this happens, that canoe should turn the card back upside down and go back to the start of the rapids. Another canoe can then try its luck. If a canoe hits a rock twice it breaks up and sinks and the whole group fails its attempt.

Canoes must move only vertically and horizontally in their attempt to shoot the rapids; they are not allowed to move diagonally.

Before the group attempts this feat, you may want to give them extra instructions depending on your knowledge of them as problem solvers and group planners. These extra instructions could be modifications such as allowing the group more rock strikes, telling them that the rapids are so loud that they can't hear each other so their is no need to talk, or making the activity more difficult by allowing them fewer rock strikes. If the group fails in its first attempt, you may want to give them time to regroup (rebuild their canoes) and try again.

"Move Over!" group initiative

MATERIALS

- about 15 feet of string or yarn

PROCEDURE

This activity works best with about 10 students.

1. Introduction

Create a large circle on the floor with the string. Explain that the students are a group of hivernants (winterers), trading goods for furs as they travel the waterways. As they go along, they continue to fill their canoe (the string circle) with an ever increasing bulk of furs which is bigger than their previous bulk of trade goods. The result is an

ever decreasing amount of space for people in the canoe.

2. All aboard!

Students must all try to fit into the large circle on the floor (start out with a big circle which is fairly easy for the group to get into). The rules are important for safety in this activity. No one above the waist or on the shoulders of someone else (this would make the center of gravity too high in the canoe and they would tip over). Stress respect for each other and treating each other carefully while attempting the task, and create other safety rules as necessary. Congratulate students when they succeed, but stress that their journey is not over.

3. Making it harder

Make the circle smaller. Students must now start to figure out how to get their group into a smaller space. Keep trying smaller circles until the group is satisfied that they have become the best traders they can be, in other words they have fit the greatest amount of furs into their canoe that they could with their number of people. They can proudly paddle into the rendezvous site with their bounty!

4. Closure

Students will probably bring up the limitations of this activity in mimicking voyageur reality. That presents a great opportunity for discussion!

"Rock Toss" game

MATERIALS

- wooden bowl
- six small flat stones of the same size (from a Lake Superior beach?)
- paint and small brush or permanent marker
- tally sheets or scratch paper
- pencils

PROCEDURE

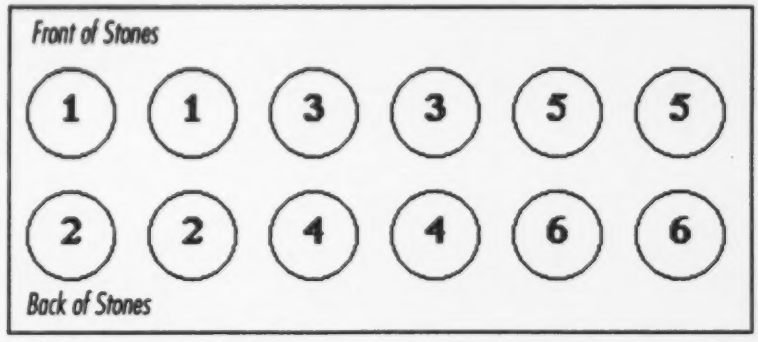
This game works best with less than 6 students.

1. Set up

Beforehand, paint or mark the stones according to the diagram.

2. Play it

Have the students stand or sit in a circle. Player one takes the bowl with the stones in it and flips the stones into the air by bringing the bowl up sharply and then jerking it down from under the stones. The player must then try to catch as many of the stones back in the bowl as possible. The points showing on the stones are then added up. Stones not caught in the bowl cannot be counted as points. Each player throws the stones twice. After the player calculates her/his total points,



she/he passes the bowl and stones on to the next player to the left. Try playing to 100 points, or try just the two turns. Real voyageurs probably used this as a betting/gambling game.

From the North American Voyageur Conference newsletter

Pea Soup Recipe

Makes 3-4 servings

MATERIALS

- 6 cups water
- 1 cup split peas
- 1/4 lb. salt pork
- 1 medium onion, diced
- 1/2 cup carrots, diced
- 1/2 cup turnip, diced
- 1 tsp. savory
- 1 tsp. salt
- 1 tsp. pepper
- 1 tsp. dry mustard
- 1 bay leaf
- 6 whole cloves
- cooking pot
- fire
- large spoon
- knife
- cups
- spoons

PROCEDURE

1. Set up

Set a cooking pot over fast fire with cold water

2. Get cooking

Boil peas until tender. When peas have partially broken down, add salt pork, diced vegetables and spices (with cloves and bay leaf tied in a loose cotton or muslin cloth bag), and bring to a slow boil once again for approximately 1-1/2 hours.

Cooking time will vary between 2-1/2 and 3 hours. Remove spice bundle before serving.

Cook outdoors over an open fire if possible. Another outdoor option would be to use fuel stoves.

Bannock (Scottish), Galette (French Canadian), Pakwejigan (Anishinabe) Recipe

Makes 8 servings

MATERIALS

- 2-1/2 cups flour
- 2 tsp. baking powder (not historically available until the 1850's)
- 1/2 tsp. salt
- 3 T lard/shortening (add to mixture only if baking)
- 1 cup cold water
- frying pan
- mixing bowl
- spoon
- spatula

PROCEDURE

Mix dry ingredients in bowl.

Cut in 3 T lard/shortening (only if baking)

Add cold water and mix enough for a soft doughy consistency.

Turn onto floured board and knead (be careful not to overwork dough).

If frying, heat and grease fry pan well with lard/shortening.

Spread or flatten pieces of dough between the heel and fingertips of hands.

Place dough into pan and fry until golden brown. Turn over and cook on the other side.

As a variation, include cooked corn, berries, or even chocolate chips in the dough! Try eating it with a little real maple syrup on top!

From Old Fort William's Voyageur Diet booklet

Voyageur Songs

Look in the following books for voyageur songs and dances:

- Blegen, Theodore C. *The Voyageurs and Their Songs.* 1966 Minnesota Historical Society.
- *12 Voyageur Songs,* Universite de Moncton male choir. Minnesota Historical Society Press.
- Hyde, Dale. *Folk Dances of French Canada.* 1977 Can.-Ed. Media Ltd. (booklet and record).
- Hyde, Dale. *Ontario Dances!* 1979 Can.-Ed. Media Ltd. (booklet and record).

Additional ideas for Rendezvous Day

- Make beads with sculpting clay such as Fimo. Create jewelry to wear or trade.
- Open a class trading post with items students bring in from home.
- Practice session with flint and steel. A local voyageur living historian may be available to help your students with this tricky skill. Be sure to provide eye protection.
- Students can research voyageur and Anishinabe canoe and paddle decorations. Buy inexpensive plain canoe paddles and have students design and paint patterns on them. Hang them in the classroom, have a drawing for them, donate them to a camp with canoes or sell/auction them as a fund-raiser.

ASSESSMENT

Students create a booklet including a character introduction, 10 event life history and a story about one of the events in their character's life.

EXTENSIONS

- In groups of 3-5, students can create plays using the characters they have developed.
- Let students plan and coordinate a living history rendezvous for younger students.

VOYAGEUR TERMS

avant: Bowman

bourgeois: Common French-Canadian term for the boss of a post. In a brigade it was the man in charge of the outfit. Americans pronounced it bushway. At an English fur post, he was called a factor.

brigade: A group of two or more canoes that were under the guidance of one guide.

ceinture: Sash.

chemise: Shirt.

commis: Clerk. Usually the person who would oversee the exchange of trade goods for furs and keep records of all transactions. He was often the only

one at a fur post who could read or write.

conges: Fur trading license.

engage: A person who signed a contract to work for a definite period of time.

gouvernail: Steersman of the canoe.

habitant: French-Canadian settler of New France.

hivernant: The "Winterer" who spends the winter in the wilds instead of returning to civilization after a summer of trading.

mangeur de lard: This somewhat derogatory term was applied to canoemen who traveled the route from Montreal to Michilimackinac or Grand Portage during the later years of the fur trade. As trade routes stretched to incredible lengths, those men from the interior posts, where pork was not obtainable, used pemmican instead and taunted the "softys" from the east with the label of "pork-eater."

Metis: People of mixed blood, the result of the "blanket" marriages between white men and Native American women.

milieux: The middle paddlers.

mitasse: Leggings.

piece: Term traders used in fur trade to describe trade goods or furs packed in roughly 90-pound units.

pipe: In fur trade, a term often used to describe a rough unit of distance from the habit of lighting a pipe once an hour.

portage: To carry a canoe or goods from one body of water to another or around a difficult areas in a river.

pose: A resting point on a portage traditionally spaced about a third of a mile apart.

sac-a-feu: Literally a "sack of fire," traditional carrying pouch, often colorfully decorated, used for carrying flint, steel and tobacco.

wattape: Roots of various coniferous trees, split in half and extremely strong and pliable when wet. Used in sewing bark sheets and lashing gunnels in the making of bark canoes.

REFERENCES

Blegen, Theodore C. *The Voyageurs and Their Songs.* 1966 (booklet and tape)

Green, Ellen B. "Fur Trade: The Companies: Partners for Profit" *Roots* Fall 1984:9

Nute, Grace Lee. *The Voyageur's Hiway.* 1969

Nute, Grace Lee. *The Voyageur.* Reprint 1987

Sivertson, Howard. *The Illustrated Voyageur.* 1994

Wheeler, Robert C. *A Toast to the Fur Trade.*

Wheeler, Robert C. *Voices from the Rapids.*

Old Fort William, Ministry of Culture and Recreation, Vickers Heights Post Office, Thunder Bay, Ontario, P0T 2Z0. Tel. (807) 473-2308

Grand Portage National Monument, Grand Portage, Minnesota. Tel. (218) 475-2202

Student Assignment Outline

I. Introduction Page

A. Name
B. Birthdate
C. Nationality
D. Occupation(s)
E. Marital Status
F. Mother's Name
G. Father's Name
H. Other Family Information
I. Residence

II. Lifeline

Construct a timeline which describes ten highlights of your life including birth and death. Remember to give exact dates.

III. A Day in Your Life

Describe the way you spend an average day in your life. Incorporate your specific knowledge of history whenever possible.

IV. A Significant Event

Write a short story which describes a significant event in your life and displays, in detail, your understanding of the fur trade and your character's role in it.

V. Bibliography

Have your students accurately document their sources. Younger students could simply list the author and title while older students use more formal documentation forms.

Unreserved Judgement

A history of the Reserve Mining company, its practice of dumping waste directly into Lake Superior, and the changing environmental attitudes of people in the Lake Superior region are the focal points of this lesson.

TOPIC
An environmental history of Lake Superior and Reserve Mining.

AUDIENCE
Grades 5-12, 15-30 students

LENGTH
PACKET—multiple class periods, 1-2 hours
RESEARCH AND/OR SERVICE PROJECT—4 hours or more, highly variable

GOAL
To evaluate students' personal attitudes toward the Lake Superior environment as they look at changes in the human relationship with the region during 1940-1980.

OBJECTIVE
- Students will gain firsthand experience of how historical information can be used as a basis for current research and environmental service.

MATERIALS
- 1-2 "Lake Superior and Reserve Mining...an environmental history" packets per student group (maximum 4 students/group); same number of blank pieces of paper for Response sheet
- Minnesota State Highway Map
- taconite pellets
- chocolate chip cookies
- paper clips
- colored pencils
- pamphlet: "Storm Sewers: The Rivers Beneath Our Feet"

BACKGROUND

One important component of developing environmental responsibility, a necessary objective for all environmental education activities, is a historical understanding of how we have arrived at where we are today as a result of individual and group decisions to act in certain ways. With such a historical perspective, we can decide to act in ways that will display understanding and environmental respect.

The information in the student packet provides a brief overview of Lake Superior and Reserve Mining environmental history.

GETTING READY

Make sufficient copies of the packet. Special preparations may be necessary for student projects as outlined at the end of this activity guide.

PROCEDURE

1. Introduction

Ask students to list and consider how people use the lake today. How do human actions today affect lake water quality? Explain to the students that we will be investigating a part of Lake Superior's environmental history to gain both a perspective on how our relationship with the lake has changed, as well as to set a context for future awareness of actions.

2. Packets

Provide small student groups with packets and allow groups to work at their own rate reading, mapping and answering questions.

3. Projects

Each student group will need to pick one of the projects listed at the end of the student packet to complete, the option of student groups designing their own project is also acceptable. In the case of the storm sewer stenciling, it may be easier logistically if all students in a given class/group are focused on the one project.

4. Closure

In order to bring the study to a close, as well as to benefit from peer teaching, plan a time when all of the students can share the project work they have completed.

ASSESSMENT

Observe students' completion of the response sheet and the northeastern Minnesota map. Observe how students complete a Lake Superior environmental stewardship project.

REFERENCES

Adamson, Wendy Wriston, *Saving Lake Superior: A Story of Environmental Action*, 1974.

Bartlett, Robert V., *The Reserve Mining Controversy*, 1980.

Lake Superior and Reserve Mining... an environmental history

INTRODUCTION

Advertisement* from the Lake Superior Daily News, 6/10/95:

ATTENTION RESIDENTS OF THE LAKE SUPERIOR SHORELINE

Great News!

Spring Dump Day is coming up! Fill your truck or a trailer and bring it down to the Lake Superior shoreline. You may dump up to one ton for free! Absolutely no cost! Bring only your household and yard wastes...old harmless scraps are fine, old furniture, glass, aluminum, paper, etc. Don't worry about hurting the fish, this material will simply settle out of the water and rest (rust?) in pieces (peace?) on the lake bottom. This method of waste disposal will help you economically, as you need not pay the expense of having your junk hauled to the dump! We all know that if people are saving money, then the economy will be stronger! Bring a picnic lunch! Dump your crud and enjoy a picnic while you watch it float away and sink—never to bother you again!

(*Well okay, this is not a real advertisement. Whew!)

How did the idea sound to you? Most residents of the Lake Superior shore line, the states of Minnesota, Wisconsin, Michigan and the province of Ontario, would be outraged by the idea of people indiscriminately dumping their garbage into the lake. Many of you may have heard of the yearly "Great Lakes Beach Sweep," a day when people come down to the lake to *clean* the beaches. All of us see recycle bins in our community (and hopefully we use them!), and some of us know that hazardous waste can be collected in a special way. Those of us who live on the lake, as well as those who like to come visit our great lake, are undoubtedly aware of human impact on Lake Superior. We realize that anything that we put in or on the ground can eventually make its way to the waters of Superior. Many people are finally understanding that we not only need to dispose of our garbage in an appropriate way, but actually must try to *reduce* our contribution to the waste stream!

WHAT'S THAT?

waste stream: The steady flow of garbage, waste, rubbish from our individual homes, businesses and communities to designated sites for waste storage.

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hazardous waste: Defined by the Environmental Protection Agency to include any substance that is flammable, corrosive, reactive or toxic. The greatest concern regarding waste usually is focused on wastes that are toxic to plants and animals.

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toxic waste: Any discarded material, commonly from industrial or commercial processes, capable of causing injury or deaths to living organisms. (Harper Collins Dictionary—Environmental Science)

In 1987 government organizations from the US and Canada signed an agreement that sets a goal of zero discharge:

> *"The discharge of toxic substances in toxic amounts be prohibited and the discharge of any or all persistent toxic substances be virtually eliminated."*
> (Great Lakes Water Quality Agreement, revision 1987)

WHAT'S THAT?

zero discharge: No dumping, no hazardous waste eliminated into Lake Superior.

Can you imagine people like yourself, or our state, provincial and/or national government, allowing a company to dump 67,000 tons of waste into Lake Superior each and every day? Well, back in 1947 one Minnesota company was granted permits for just such dumping! Only one small group of Minnesotans opposed the action. The company permitted to dump into the lake was the Reserve Mining Company and the group in opposition was the United Northern Sportsmen Club.

Why have our values changed? Why is it that a company was given permission from the government to dump waste directly into Lake Superior back in the 1940s, 50s and 60s, but that permission was taken away in the 1970s and would not be allowed today? Discuss this question and write down your group's idea on the response sheet (Response #1).

WHAT'S THAT?

value: a principle with desirable characteristic.
For example, a person might value a clean Lake Superior and believe that dumping waste into Lake Superior is wrong.

Let's take a look at this part of Lake Superior history. Remember, history is science, and history is geography; thus, don't be surprised to find maps and projects ahead! You will need your North Shore/Lake Superior map, your Minnesota State Highway map, your response sheet and a pack of colored pencils.

One to two billion years ago, the Mesabi Iron Range was formed when iron was deposited from ancient seas covering the land that is now northern Minnesota. Eventually the seas receded and the deposits were compressed into an iron-bearing rock that we now call taconite. Weathering of the rock has further processed this resource; the rain water softened the rock and dissolved out some of the sands and other materials, leaving a high concentration of iron-ore.

MAP IT!

The Mesabi Range is approximately 120 miles long and one to three miles wide, and is located just to the southwest of another iron range, the Vermilion. To map this area of rich iron ore deposits, draw a fuzzy red line on the North Shore/ Lake Superior Map, running from just east of Ely (this is the Vermilion range area) and down in a southwest arc past the towns of Eveleth, Virginia, Chisholm, Hibbing and ending to the SW of the Grand Rapids area. This fuzzy line should appear as a long and narrow band. Label the Eveleth to Grand Rapids area "Mesabi Range."

In 1866 the Merritt brothers discovered a soft red iron rich soil north of Duluth. Soon after the discovery in 1871, the first testing for minerals on the Mesabi Range was initiated. In 1920 the mining operations of the Mesabi Iron Company began construction of a plant for processing the taconite (removing the iron ore from the rock), as well as the construction of a railroad and a town for employees! The town is called Babbitt, Minnesota.

MAP IT!

North Shore/Lake Superior Map—Mark and label the town of Babbitt on the Mesabi Iron Range with a black dot.

WHAT'S THAT?

taconite: A hard rock containing about 30% iron in the form of fine specks of iron oxide.

FEEL IT!

Look closely at the taconite pellets provided by your teacher. These pellets are the final outcome of the mining and processing of the iron bearing rock.

COOKIES

Your teacher should supply you with 2 chocolate chip cookies and a paper clip. (DON'T EAT—not yet anyhow!) Pretend that the chocolate chips in the cookies are like iron-bearing rock in the earth.

STEP ONE:
Remove the chocolate chips from one of your cookies (using the paper clip extractor!), how do the reserves of ore in your rock compare to that of your neighbor?

STEP TWO:
Now remove the cocoa from the chocolate chips, dump the rest of the material on the floor…just kidding! Well, it may prove impossible to separate the cocoa from the chips, but perhaps you get the idea of how this activity is to represent how taconite was extracted from the iron bearing rock, and how the waste matter was dumped.

STEP THREE:
Eat your mess!

In 1939 the Reserve Mining company was organized. Over ten years later, Reserve began to build a plant to process its taconite on the shoreline of Lake Superior. This was undertaken after the company was granted all the permits necessary for operation (permits and permission from the state to carry out their plans). Fishermen were the only group to voice any opposition to the plans of Reserve Mining. United Northern Sportsmen, a sport fishing group, along with some commercial fisherman, were concerned about the impact of the waste on fish populations in the vicinity of the Silver Bay site. A railroad, a harbor and the building of a town were undertaken at a location a few miles east of Beaver Bay, Minnesota. This site is called Silver Bay.

MAP IT!

North Shore/Lake Superior Map—Put a dot in the correct locations of the towns of Beaver Bay and Silver Bay, label the dots. Draw a line connecting the towns of Babbitt and Silver Bay. This is an approximation of the railroad route for the transport of taconite between the mine and the processing plant. Label the rail line, perhaps "taconite train."

By 1955, much of the high grade ore of the Mesabi Range had been mined. However the mines still contained vast quantities of the lower grade ore, taconite. The first load of taconite arrived at the Silver Bay plant for processing in 1955; in 1956 the first load of iron pellets were shipped out of Silver Bay. Soon, 67,000 tons of waste from the process of extracting the iron from the taconite rock were being dumped into Lake Superior each day. Tiny particles of iron, silicates and other materials made up the waste being dumped into the lake.

MAP IT!

North Shore/Lake Superior Map—Draw a large #67,000 with a green colored pencil on the map in the waters outside of Silver Bay.

PHOTO!

Check out the photo of Reserve's dumping into Lake Superior (see next page). Discuss your reaction to the photo. Jot down a sentence or two about your reactions and feelings on the response sheet (Response #2).

In 1963, a senator from Wisconsin, Gaylord Nelson, started to enquire about the possibility of taking action against Reserve based on water pollution laws. In 1965 a National Water Quality Laboratory was established in Duluth, Minnesota. This site is now called the Environmental Protection Agency Water Quality Laboratory, and is located immediately east of Duluth along the lakeshore.

MAP IT!

North Shore/Lake Superior Map—Mark the city of Duluth with a black dot and label it, mark the water quality lab with the following label: H_20 LAB.

Two very important people came onto the Lake Superior/Reserve Mining scene in 1967. One was a lawyer from Minneapolis, Grant Merritt. Notice the name and look back to the year 1866, Grant is a descendent of the men who originally discovered the iron on the Mesabi Range! Like many others, Merritt noticed large patches of "green water" out on the lake while traveling along the North Shore; Merritt wondered if this water discoloration was related to the activities of Reserve Mining in Silver Bay. Merritt is credited with taking one of first activist involvements in the issue of Reserve Mining's waste dumping in Lake Superior.

WHAT'S THAT?

activist: A person involved in direct, vigorous action in support or opposition to one side of a controversial issue.

The other important activist coming onto the scene in 1967 was a woman named Verna Mize. Mize is credited with undertaking a one-woman crusade

PHOTO: Reserve Mining dumping into Lake Superior. 1979 Star-Tribune/Minneapolis-St. Paul, staff photo by Mike Zerby.

against the actions of Reserve Mining Company after learning about the dumping of waste into Lake Superior. The feeling that the dumping was wrong started to spread in the late 1960s. In 1968, the Democratic Farmer Labor political party came out in opposition to any dumping of waste into Lake Superior. A report that seriously questioned the actions of the Reserve Mining company's dumping of waste into Lake Superior was leaked to the press in 1969. Also that year, a group of concerned citizens called Save Lake Superior Association was formed. The concern about the pollution of Lake Superior grew in the early 1970s. Eventually, Reserve was taken to a federal district court to determine whether its operations were breaking pollution laws.

In December of 1972 the whole issue took a big turn! No longer was the focus of the attention on whether or not Reserve was polluting the air and water of Lake Superior, but rather the attention turned to whether the actions of Reserve Mining was putting all residents of the shore of Lake Superior at risk! The president of the Save Lake Superior Association, Arlene Lehto, made public the resemblance between some of the waste that Reserve was dumping into Lake Superior and the cancer causing agent, asbestos.

WHAT'S THAT?

asbestos: A substance used in the building industry for thermal insulation, soundproofing, roofing, electrical insulation and prevention of electrical fires. Asbestos is comprised of fibrous magnesium silicate minerals and minute particles, which can become airborne and can be inhaled by persons who come in contact with the material.

The public health question led to many changes on the North Shore. People wondered if the fibers, when ingested, could lead to health problems. Many people started to use bottled spring water for drinking instead of their tap water from Lake Superior. Duluth did not have a filtration system for Lake Superior water when the concern first surfaced. In fact, it was the asbestos public health concerns that served as the impetus for Duluth to build a water treatment plant in 1975.

A MEMORY FROM CHILDHOOD

I remember being 12 years old and taking a family trip to Duluth and the North Shore in 1976. My family stayed at Spirit Mountain, which I thought was the greatest—octagonal buildings, wow! I also remember picking up cartons of drinking water from the Plaza IGA store on Superior Street. The notion of drinking water in cartons was so foreign to me, I found it incredible and bizarre; especially given I was seeing the greatest of the Great Lakes for the first time...all that water, and none of it drinkable?? The strong reactions have stuck with me over the years. Later on the same trip my family and I must have driven right by the dumping at Silver Bay. I do not remember that; all I remember from the North Shore is climbing rocks and splashing in rocky-shoreline pools of glorious sun-warmed water—thus began my love affair with Northern Minnesota and Lake Superior.

Can you remember an event from your childhood that you feel has strengthened your connection to the natural world? Jot down your thoughts on the response sheet (Response #3).

Eventually, it became clear that the courts were not going to allow Reserve to continue its practice of dumping waste directly into the Lake. The problem was not so simple as where to dump; there was a big concern for the people of Silver Bay and Babbitt too. Any change in Reserve's practices meant potential upheaval for all the employees of the company.

BEST COPY AVAILABLE

PROBLEM SOLVING

Imagine that the year is 1970 and your group has just been hired by Reserve Mining to save the operation! Many hard working people in Silver Bay and Babbitt depend on Reserve Mining! Can your group come up with an alternative to the dumping of mining waste in Lake Superior? A plan that will keep the residents of Silver Bay and Babbitt employed, Reserve profitable, and the lake safe from mining wastes? Outline your plan on the response sheet. Also, anticipate the unknown! What issues, concerns or logistics might make your idea problematic? What specifics might you not know about? Jot these down, too (Responses #4 and 5).

As one possible solution, Reserve Mining company proposed the creation of a deep pipe that would deposit taconite wastes further from the shore and in very deep water. This deep pipe plan was the official Reserve Mining Co. proposal between the years of 1969 and 1974. Scientific findings such as internal waves, bottom currents, winter thermoclines, etc., provided questions as to whether or not a deep pipe into the lake would be any better than the existing waste disposal of direct nearshore dumping. The deep pipe was not to be! By the early 1970s, the Governor of Minnesota (Wendell Anderson) was talking about "zero discharge into Lake Superior." The Environmental Protection Agency had also adopted a total on-land disposal requirement for the taconite waste.

Seeking solutions from differing perspectives often leads to further controversy; the next waste disposal plan proposed by Reserve was an example of how the controversy continued! Reserve Mining, after abandoning their idea of a deep pipe into Lake Superior for waste disposal, went to work on a proposal for dumping waste in the Palisade Creek Valley—a location just north of Silver Bay. It is understandable that Reserve did not like the idea of on-land disposal as it meant a much greater expense for their operations. (It is interesting to note, however, that other Minnesota mining operations were both disposing of waste on-land *and* earning a profit!)

Reserve argued that the Palisade Creek site was an appropriate site for a number of reasons including the steepness of the valley, which would create a reservoir that would be deep without a great surface area. Reserve also contended that: "...the Palisade area was similar to other parts of the north shore; moreover, the Palisade area was extremely inaccessible, and of minimum value for timber, wildlife, camping, hiking or fishing." The Minnesota DNR argued that the area was environmentally significant and was under consideration (since 1962) for the site of a future state park. The judge in the court case between Reserve and the State of Minnesota eventually made a trip to the Palisade Creek area to help him evaluate the testimony, Judge Miles Lord concluded:

"The Palisade Creek area does indeed have everything and that is what makes it unique among other North Shore areas. It has high hills, bluffs, bogs, mountain lakes,

steep slopes, rock outcroppings and waterfalls. The area contains virgin timber including 200-year-old white pine. The area is unique in that it contains the entire realm of arboreal vegetation from conifers to hardwoods. There are trout streams in the area. The area is the natural habitat for white tailed deer, moose, beaver, grouse, fishes (sic), pine martin and wolves; the last two being in danger of extinction. The very fact that the area is semi-mountainous with high hills, clustered lakes, with bogs in between, gives the land a significance that cannot be found anywhere else on the North Shore."

Interestingly enough, the State of Minnesota must have agreed with Judge Miles Lord because today the Palisade Creek is a part of the Tettegouche State Park, the area also now hosts one of the finest stretches of the Superior Hiking Trail!

MAP IT!

North Shore/Lake Superior Map—Tettegouche State Park. Find the park on your highway map and then mark and label the area on your North Shore map with an suitable symbol of your choosing. Check the location on the Superior Hiking Trail map below.

Other disposal ideas that surfaced included the dumping of waste at a site midway between the Babbitt mine site and the Silver Bay processing plant, and the proposal to return the waste to the pits that the iron was originally mined from. The plan that won eventual approval was called the Mile Post 7 plan. Mile Post 7 was a large basin created by the construction of 5 major dams with a total dam length of 26,700 feet. It was a site close to the Silver Bay plant, along the Babbitt-Silver Bay rail line; the site was located approximately 3 miles from Lake Superior at 600 feet above lake level. By 1978, all permit disputes were resolved and both the state of Minnesota and the Reserve Mining Company agreed that Mile Post 7 would open by 1980 and the disposal of waste into Lake Superior would finally end at that time. By the time that the dumping of taconite tailings into Lake Superior was stopped (April 1980), over 400 million tons had been deliberately discharged into the lake.

MAP IT!

North Shore/Lake Superior Map—Draw a brown patch just west of Silver Bay and label it Mile Post 7 tailings dump.

Throughout this long controversy (1947-1980), it was never actually established that significant environmental harm was occurring, nor was there "proof" of a human health hazard—although there was a lot of evidence that supported these two generally held beliefs. There was a great deal of evidence regarding effects of asbestos fiber inhalation, but not much documentation of the risks of ingested asbestos fibers (via drinking water). Thus, what the Reserve Mining controversy boils down to is a change of values: people were beginning to think and act very differently regarding the natural environment. It is not a coincidence that the very first Earth Day was held during the time of the North Shore controversy (1970), our entire nation was waking up to the realization that we needed new attitudes and relationships with our natural world.

ATTITUDES

Can you think of environmental attitude or behavior changes that you have witnessed during your lifetime? Many people never used to recycle. Now, probably your family and all of your friends recycle anything that they can. On your response sheet, jot down an environmental attitude/behavior change that *you* have witnessed in your lifetime (Response #6).

ACTION!

Now that you have read a chapter of Lake Superior environmental history, it is time to get active. Below you have a number of project choices that will enable you to research this case further, look into current waste disposal methods or work to prevent waste from entering Lake Superior. (This is the best part!)

- hazardous wastes in your community
- historical research via the newspaper and other past/current sources.
- current Lake Superior water quality issues
- stormwater sewer stenciling
- your idea here:

PROJECT 1: HAZARDOUS WASTE IN YOUR COMMUNITY

PART 1

According to a 1991/92 environmental analysis (the Green Index), Minnesota was found to release 776.1 pounds of toxic chemicals per square mile per year! This gives Minnesota an 18th place rating against all other states (first place being the lowest amount of toxins released). Do you know the hazardous wastes that exist in your community? Interview a representative of the waste disposal operation in your community—for example, Western Lake Superior Sanitary District (WLSSD) in Duluth and surrounding Minnesota communities. Or, interview a representative of your local environmental protection agency to obtain the information needed to complete the included chart at the end of this packet.

PART 2

What about the hazardous wastes in your home? What kind of household hazardous waste collection is carried out in your community? Interview one of the above mentioned representatives to find out what items in people's homes are hazardous, and what can be done to safely dispose of such items. Or, if in the Duluth area, arrange a trip to the household hazardous waste collection center at the WLSSD.

PROJECT 2: HISTORICAL RESEARCH VIA THE NEWSPAPERS

The Reserve Mining environmental history provided in this lesson is really just a brief overview of a complex situation that spanned four decades. Here is a chance to delve into the case much deeper! Pick a topic related to the history, for example:

- Citizen involvement in the effort to stop Reserve dumping
- Community reactions in Babbitt and Silver Bay to the effort to stop Reserve from dumping
- The Stoddard Report! What was it? Why was it important to the Reserve case?
- The changing Minnesota state environmental policy during the period 1940-1980
- Mining and community life in Babbitt and Silver Bay since the cessation of lake dumping in 1980
- The role of Judge Miles Lord in the Reserve mining controversy
- Your idea here:

Now take a trip to your public library and using the Minneapolis Star, The Minneapolis Tribune, the Duluth Herald and/or the Duluth News Tribune find a minimum of 10 newspaper articles that help you to understand your topic. Create a booklet, oral report or poster board to share your "news" with others!

PROJECT 3: CURRENT ISSUE

Lake Superior water quality is a constant concern here in the northland. Explore a current issue that has a connection to the quality of water in Lake Superior.

- The North Shore "Safe Harbor" controversy. What is it? How does the plan affect water quality? What is the current status of the idea?
- Department of Defense waste barrels in Lake Superior...what is in them? Why were they dumped? Should they be removed from the lake bottom?
- Zebra mussels and other alien species in Lake Superior. What is the impact that alien species have had/are having in Lake Superior? How have people encouraged alien species in Lake Superior? Are there programs in place to limit alien species from spreading in Lake Superior?

• Your idea here:

This project will require both a public library trip as well as calls to various environmental agencies in order to obtain the most up to date information. Possible sources of information include:

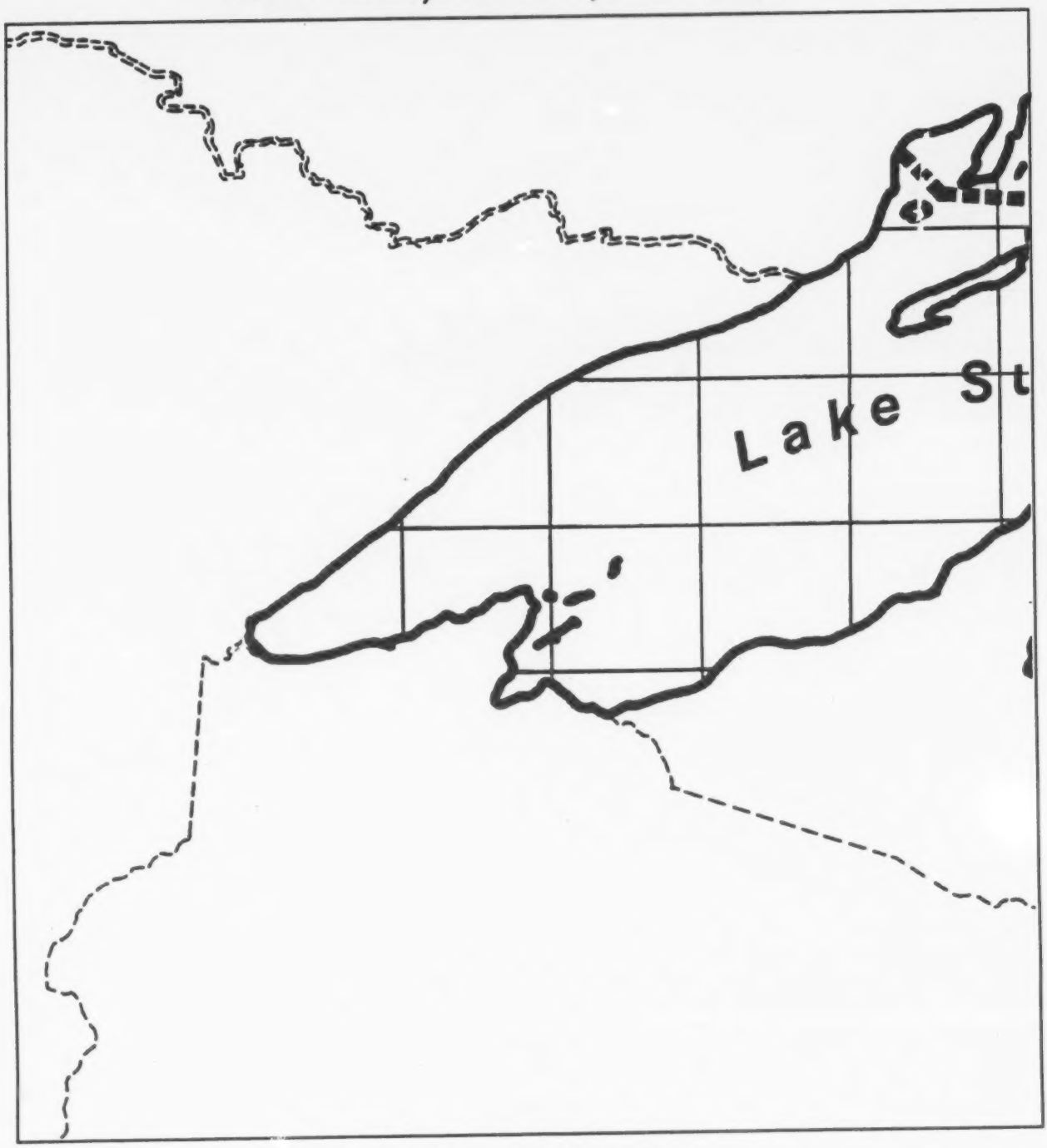
• State or provincial pollution control agency
• State Sea Grant office
• Lake Superior Center
• State department of natural resources (or provincial ministry)

PROJECT 4: STORMWATER STENCILING

We see storm sewers daily as we pass through the towns and cities in which we live, they seem to be everywhere…but where do they go? On the hillside in Duluth rain and melting snow travel through the storm sewers into Lake Superior. In other towns, storm sewers transport stormwater into the nearest river, wetland or lake. So, it follows that anything in our parking lots and on our streets will be transported along with the stormwater into the lakes, rivers and wetlands of our area! Think about some of the things we find on our streets: leaves, motor oil, automotive antifreeze, litter, pet waste, gasoline and on and on! We wouldn't directly dump any of these things into lakes, rivers and wetlands, thus, we must do our best not to dump *indirectly.* This action is directly linked to work that the US Environmental Protection Agency has underway. The Great Lakes Reduction Initiative is addressing many sources of pollution, including city street water runoff. Painting reminder messages about storm sewer dumping, *right on the street,* along with neighborhood education, is what storm sewer stenciling is all about. Contact Lake Superior Center for information about storm sewer stenciling in your community.

The University of Wisconsin-Extension (UWEX) has printed a publication entitled, "Storm Sewers: The Rivers Beneath Our Feet;" this publication is an excellent resource for learning about storm water, storm water sewers, road waste and problem control. Your teacher will provide this publication for your group to read.

North Shore/Lake Superior Map

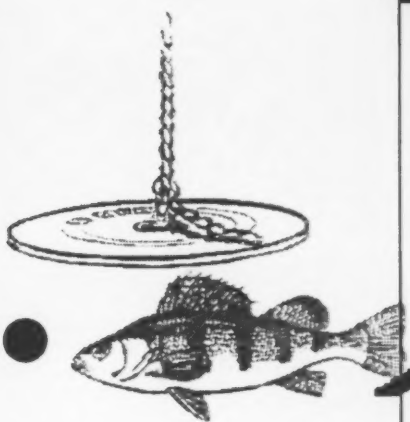


Map used with permission from Our Great Lakes Connection

Hazardous Wastes in Our Community

Hazardous Waste	Major Source (s)	Health Hazard (s)

*Lake*Effects



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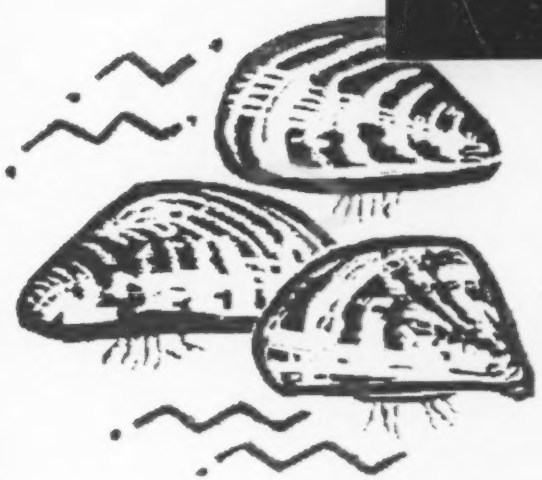

Lake Superior Quiz Show

How much have you learned about Lake Superior? Students are divided into teams to answer questions about Lake Superior in a quiz show format.

TOPIC
Facts and trivia about Lake Superior.

AUDIENCE
Grades 4-8, 10-30 students

LENGTH
45 minutes

GOAL
To learn or review facts about Lake Superior in an interesting way.

OBJECTIVES
- *Students will work cooperatively with their team to answer (and/or write) the questions.*
- *Students will appreciate amazing aspects of Lake Superior.*

MATERIALS
- *Lake Superior questions (examples below)*
- *chalkboard or paper*

GETTING READY

Specific questions can be written by the teacher to closely match the course of study and to provide an appropriate review.

Draw the game board on the chalkboard (see sample Quiz Show chart on the next page). If not already set up in work groups, organize the classroom so that students can sit in teams; determine appropriate team size based on the group. Students sit roughly in a circle.

PROCEDURE

1. Introduction

Explain the procedure for the game. Choose one student to keep score (i.e. keep track on the board of the "money" each team has earned). Divide the class into teams. Each team selects a leader to give the answers.

2. Run the game

One team chooses a category and amount. Place an X in the corresponding box and read the corresponding question. The team is given 30 seconds to discuss the question. When time is up, the leader answers. If correct, award the "money" and play goes to the next team.

If a team answers the question incorrectly, the other teams have a chance to answer, starting with the team to the left.

Play always resumes with the team to the left. If a team answers a question correctly, play still resumes to the left to give everyone a fair opportunity.

Examples:

- Team 1 answers a question correctly and receives the "money." Play moves to the team to the left, Team 2.
- Team 1 answers incorrectly. Team 2 answers, but incorrectly and Team 3 answers correctly. Play resumes to Team 2, the team left of Team 1.

Continue playing until all the questions have been chosen.

3. Final Challenge

Team members decide among each other what to wager from their earnings. They write the amount on paper and give it to the person keeping score. If the team answers the question correctly, add the amount they wagered to the money they have earned for an overall total. If the team answers the question incorrectly, subtract the amount they wagered from the money they have earned for the overall total.

4. Closure

The team with the most "money" after "Final Challenge" is the winner. But of course the real winner is Lake Superior, because now that the students know all these wonderful things about the lake, they'll take better care of it.

ASSESSMENT

Students will demonstrate cooperative behaviors as they work together to answer questions about Lake Superior.

EXTENSION

- Have students research Lake Superior and develop their own questions for different quiz categories.

Lake Superior Quiz Show

SAMPLE QUIZ SHOW CHART

Weather	Lake Creatures	Lake Facts	Water	Fish	Economy	Geography	Pollution
100	100	100	100	200	200	200	200
200	200	200	200	400	400	400	400
300	300	300	300	600	600	600	600
400	400	400	400	800	800	800	800
500	500	500	500	1000	1000	1000	1000

LAKE SUPERIOR QUIZ QUESTIONS

Weather

$100	The average annual temperature of Lake Superior is 20°F, 40°F, or 55°F	*40° F*
$200	When this melted, the Superior basin became filled with water.	*Glaciers*
$300	When warm air flows out over the cold lake and the moisture in it condenses, this occurs.	*Fog*
$400	Gales with strong winds and rain occur when low pressure systems pass over the lake, and are called this.	*Northeasters*
$500	A tidal-like rise and fall caused by persistent strong winds accompanying a high pressure system "pile-up" of water against the lake's windward shore is called this.	*Seiche (saysh)*

Lake Creatures

$100 This sea creature can destroy up to 40 pounds of fish in the 12-18 months it spends in the lake. *Sea lamprey*

$200 Scientists suggest this is the way that Zebra Mussels have entered Lake Superior. *In the ballast water of ships .*

$300 This mammal appears to spend much of its time playing, sliding and swimming and chasing things. *River otter*

$400 Once endangered, this animal is returning to nest on North Shore cliffs. *Peregrine Falcon*

$500 Scientists fear that this perch-like fish introduced from Europe might spread and reduce Great Lakes whitefish and yellow perch populations. *Ruffe*

Lake Superior Facts

$100 The deepest part of Lake Superior in feet. *1333 feet (approximately 1330 feet)*

$200 The width of Lake Superior is 62, 119 or 160 miles. *160 miles*

$300 180, 242 or over 300 ships have sunk in Lake Superior. *Over 300 ships*

$400 If the shoreline of Lake Superior was unraveled to create a highway, how many miles would it be: 894 miles, 1365 miles or 2726 miles? *2726 miles (distance from Duluth to Miami)*

$500 Lake Superior's drainage basin is how many square miles: 49,300 square miles, 54,679 square miles or 78,461 square miles. *49,300 square miles*

Water

$100 What percent of the world's water is fresh water? *2.8%*

$200 This lake contains a greater volume of fresh water than Lake Superior. *Lake Baikal in Siberia or Lake Tanganyika in Africa*

$300 What percentage of the world's surface fresh water does Lake Superior hold? *10%*

$400 Glacial Lake Duluth was how many feet above the present lake level: 328 feet, 169 feet, or 602 feet? *602 feet*

$500 Name 1 of the 2 largest tributaries to enter Lake Superior. *Nipigon River in Ontario; St. Louis River in Minnesota/Wisconsin*

DOUBLE CHALLENGE

Fish

\$200 Originally, these were the only two types of trout found in Lake Superior. *Lake trout and brook trout*

\$400 This is an exotic fish species whose spiny fins make it an unappealing meal for many other fish. *Ruffe*

\$600 When this fish became abundant, the herring became scarce. *Rainbow smelt*

\$800 This fish is the largest species (in physical size) in Lake Superior. *Lake sturgeon*

\$1000 Name two of the three reasons why the fish population in Lake Superior has declined. *Pollution, over fishing, introduction of exotic species.*

Economy

\$200 The main export transported by foreign vessels across Lake Superior is? *Iron ore*

\$400 Cook County, Minnesota depends heavily on this for most of their economy. *Tourism*

\$600 Rumor of this mining ore brought prospectors to the North Shore during the 1840s-1850s. *Copper*

\$800 Name two of the four industries that have provided the most jobs for people along the North Shore. *Logging, mining (early years), commercial fishing, and tourism (today)*

\$1000 Name 3 out of 6 major exports Lake Superior is known for shipping. *Grain and other agricultural products, western coal, iron ore, steel, limestone and cement.*

Geography

\$200 This lake's French names included Lac Tracy and Lac Conde. Its Anishinabe name is Kitchi-Gammi. *Lake Superior*

\$400 The largest inland port in the United States is this. *Duluth/Superior*

\$600 Lake Superior borders how many states? *3 states—Minnesota, Wisconsin and Michigan*

\$800 This canal, allowing ships to bypass Niagara Falls allowed the sea lamprey to enter the Upper Great Lakes. *Welland Canal.*

\$1000 These are the two most common rocks found around Northern Minnesota: a. basalt and gabbro; b. limestone and dolomite; c. quartz and mica. *a. Basalt and Gabbro*

Pollution

$200 This causes over 50% of Lake Superior's pollution. *Airborne toxins/atmospheric deposition*

$400 Low concentrations of nutrients, suspended sediments and organic materials gives Lake Superior an average underwater visibility of 10 to 20 feet, 25 to 45 feet, or 50 to 75 feet. *50 to 75 feet*

$600 Mercury and PCB pollution accumulate mainly in which part of a fish? *the fat (fat of the back, sides and belly)*

$800 Name 2 of the 5 major sources of Lake Superior pollution. *a. the atmosphere; b. municipal and industrial discharges; c. farmland and municipal runoff; d. contaminated groundwater; e. contaminated sediments.*

$1000 Due to this, Lake Superior is not as polluted as the other Great Lakes. *Lake Superior's shores are not as developed with cities and industries as the other Great Lakes.*

Final Challenge–Lighthouses

Name one of the two reasons why a lighthouse is important on Lake Superior.
During a severe storm, it helps provide for a ship's safety; around areas of iron a ship's compass goes off course. A lighthouse keeps a ship on course.

A "How-To" Guide on Taking a Field Trip to Lake Superior from 150 (or more) Miles Away

WHO?

This guide is based on the experiences gained from a trip run for 21 to 30 Minneapolis children and up to nine accompanying chaperones every spring since 1986.

WHY?

The main purpose in going to "the lake" is to make the opportunity available for school children to see, feel, hear, touch and sometimes even taste, the beauty and wonder of Lake Superior. The fact that we have the largest freshwater lake in the world at our doorstep is awesome and it is great to share this resource with the students. The trip can be a part of a very directed lake study, a part of an intercurricular "Minnesota Study," (or your own state or province) or perhaps a part of an outdoor recreation adventure.

WHEN?

May, June and September are the ideal months for Lake Superior school tripping. Often this trip is taken on the Wednesday, Thursday and Friday in the second to the last week of school. This means it is anywhere from the last week in May to the last week in June, depending on your school calendar.

WHERE?

In Minnesota, camping at the Jay Cooke, Gooseberry or Split Rock Lighthouse State Park campgrounds works well. Reserve as many campsites as needed, which is usually from five to seven. Try to keep them close to each other as well as the restroom and shower facilities building. This is not group camping and you will need to decide if this is appropriate for your group. There are group camping sites at Jay Cooke and Gooseberry State Parks. Not using a group campsite requires maximum trust on your part and a tremendous amount of personal responsibility on your students' part. It is important that they understand and respect the rights and wishes of the other campers in the park. Camping at a group site does make the chaperones' job easier.

Jay Cooke State Park	*(218) 384-4610*
Gooseberry Falls State Park	*(218) 834-5350*
Split Rock Lighthouse State Park	*(218) 226-3065*
MN State Park Reservations	*(800) 246-2267*

Other recommended camping options around the lake include: Big Bay State and City Parks, Madeline Island, Wisconsin; Pictured Rocks National Lakeshore, Munising, Michigan; Lake Superior Provincial Park, Michipicoten, Ontario; and Pukaskwa National Park, Hattie Cove, Ontario.

HOW?

Lots of planning!!!

The following is a list of steps to go through to make this happen.

1. Bureaucracy

Check with your district offices to be sure a trip of this nature is approved for students of the age you teach. An example of a form from one school is "Request for approval for overnight or extended trips." This usually needs to be done at least one month prior to leaving. Your district may have similar requirements. It includes purpose of the trip, background preparation, itinerary and supervision.

2. Early planning

Begin discussing the trip in the fall. This gives plenty of time for feedback from students and their families and, most importantly, allows time to engage enough parents to drive and act as chaperones.

3. Getting help

Enlist parent chaperones/drivers for your trip. (You could charter a bus, but this will cost more money.)

4. Insurance

Check with your district on insurance needs for overnight trips for students and for drivers carrying school children. You may be required to purchase "Campers Insurance." This is done through the district. It costs $0.20 per day for each person to be covered. The coverage benefits are $2500 Accidental Death and Dismemberment; $2500 Accidental Dental/Medical Combined, and has a $25.00 deductible. Most families do have protection under private insurance plans, group plans through their employment or homeowners insurance. Many of these policies will also cover student injuries incurred during school activities. (All amounts are in US dollars)

You may also be required to have copies of the drivers' personal vehicle insurance. To drive children they must have $100,000/300,000 coverage and each child must wear a seat belt. If a driver does not carry this type of insurance it may be purchased as a special rider for the days necessary at very little cost.

5. Raising money

Plan fund raisers or enlist parents to plan and run them. The trip can usually be taken for about $30 per student. Try to raise as much money as possible for each student. Chaperones go free. Try to do one big fund raiser per class each year. One very successful venture during the last six years has been to sell tubs of fudge at holiday time. If you can establish a regular fund raiser like this, school families watch and plan to take advantage of it on a regular basis, thus eliminating some of the advertising work each year.

6. Activities

Plan and make reservations for your field trip activities on the way to the lake, while at your campground and for the return trip home. A good guideline is to have one "educational" activity on the way to the lake on Wednesday, another on Thursday morning and one more on the drive home Friday. These activities are usually centered around the history of the area and/or Minnesota in general. For Minnesota groups, tours scheduled with guides at the following places work well:

- The Fur Trading Post in Pine City, run by the Minnesota Historical Society
- The Fur Trading Post, run by Tobies in Hinckley
- The Duluth Zoological Gardens in Duluth
- The Depot Museum (St. Louis County Heritage and Arts Center) in Duluth
- Canal Park and the Canal Park Marine Museum in Duluth
- Glensheen Mansion in Duluth
- S.S. William Irvin Ore Boat Tour in Duluth
- A harbor cruise aboard the Vista Fleet in Duluth
- A train ride with the North Shore Scenic Railroad and a visist to the Transportation Museum at The Depot in Duluth
- Tours with naturalists set up in Split Rock and Gooseberry State Parks
- Split Rock Lighthouse Tour
- The fish Hatchery at French River
- A trip aboard the Grandpa Woo—out of Two Harbors
- The Historical Society Museum in Two Harbors
- Trips over the Aerial Lift Bridge to Park Point in Duluth
- Tom's Logging Camp north of Duluth
- **And, of course, the Lake Superior Center in Duluth.**

There are many more things to do, just not enough time. You might reference a book published by Marlor Press, Inc. in 1993, *Lake Superior, Wow!*, written by John Murray. This book will give you much of the information needed to make the necessary contacts. The Minnesota Historical Society brochures are also helpful.

A thematic Lake Superior trip using history, Anishinabe and/or Voyageur, is a great possibility. Consider stops at the National Monument in Grand Portage, hiking on the Grand Portage, a visit to Old Fort William in Thunder Bay and camping at Judge Magney State Park. Given the distances involved, this type of trip would require special considerations.

GETTING READY TO GO

This is the most challenging part, as you're trying to do this and still teach everyday.

Six weeks before leaving

Send home a preliminary slip which asks the following things: If each family intends for the child to be a participant on this trip; drivers to firm up their commitments and tell how many seat belts they have available for children; which families have tents that can be used (they need to be easy enough to put up!); and the amount of money that will be requested. It is best to make this a check off sheet which will be returned to you so that you have a record to refer to if needed.

Be sure to have filed the appropriate papers with your district according to their timelines. Make sure to copy school medical forms for each student. Each form should have an emergency contact number; if not, add this information request to the permission slips. Medical forms need to be kept locked, confidential and must accompany the group on the trip.

Two weeks before

Send out a letter with the final information, the itinerary, the invitation and contract for participation and a packing list. (The "invitation" is a list of expectations that children and their families must agree to before leaving. This is helpful later as a reminder to students during the three days. Sometimes being away from home, camping and having a lot of fresh air and outdoor activities can cause irritations.) A sample letter is included at the end of this section.

One week before

Have copies of all of the drivers' auto insurance placed in a file to be kept back at school. Give the school clerk the number of the campground where you are staying, the itinerary and student pick-up information so that she/he has it when parents call school with questions.

Arrange to have three or four students stay late at school the night before the trip and help with grocery shopping. Parents may also be enlisted to do the shopping.

Set up tent groups. Be sure to actually set up all tents prior to the trip. Make sure there is space for all, including the chaperones.

Three days before

Firm up the menu for group meals with the children. Make sure that the children are all comfortable with the food and that they are part of the decision for menus. The leaders, however, should maintain veto powers over the food quality and the easiness of preparation in the campground. Have the students pack a bag lunch for the trip up on Wednesday, prepare group dinners on Wednesday and Thursday, breakfast on Thursday and Friday and lunch on Thursday. On the way home on Friday stop at a fast food restaurant. They are usually friendly and welcoming to large groups. Here is what we typically have :

BREAKFAST:

Several large boxes of dry cereal, bagels, cream cheese, jelly, peanut butter, butter, fruit, fruit juice and milk. Have hot water available for coffee, tea and hot chocolate.

LUNCH:

Supplies for sandwiches, including rolls, turkey, ham, cheese, peanut butter, jelly, lettuce, sprouts, mayo, mustard. Complimentary items including chips, fruit, pickles and a treat (cookies, granola bars or fruit roll-ups), lemonade. It is best to have this be a meal that could be packed into brown paper bags and carried for hiking if necessary.

DINNER:

Spaghetti with meatless sauce, garlic bread, carrots, milk, lemonade and apple slices dipped in caramel works well for one day. Tacos, refried beans (for the vegetarians), carrots, s'mores and beverages work well for the second day. These meals are easy to prepare and need a minimum of large pots and pans. Divide the campers into four groups and each group must take a turn setting up and preparing the food and do clean-up duty for that meal. The adults take responsibility for breakfast on the last day as kids are busy packing and taking down their tents.

Campers are required to bring a sturdy plate, cup and eating utensils with them that they wash and reuse for each meal. Visit garage sales and ask families

for donations of wash tubs, old pots and pans, cooking utensils, extra silverware, dish towels, sheets to use as table cloths, etc. Keep a cupboard at school for all of the camping supplies and add to it each year.

Drivers are asked to bring empty coolers that we fill with the food the morning of departure.

If it can be arranged, drive a large van so that the coolers, food and cooking and cleaning supplies can be stored in the van except at meal times. This also makes extra space for large tents and sleeping bags, etc. that do not fit in the drivers vehicles.

Two days before

Set up car groups, making sure there are seat belts for everyone.

The day before

Review meal, tent and car plans. Go thoroughly over expectations. After school on this day take three or four students grocery shopping. The leader handles the list and they fetch, push carts and make decisions on types of cereal, jelly, etc. Buy each of them a treat at the end as "thanks."

The morning of

Pack coolers. Try to have each child get their belongings into the vehicle they are riding in. Roll out and good luck!

Other things worth mentioning

On a trip this far from home kids need a delicate balance of freedom and security from you. The other chaperones will not be looked upon as the ultimate authority/salvation. That is always the lead teacher.

Although all of the side trips and planned activities are appreciated by the kids and "good for them," they particularly enjoy playing by the lake, climbing cliffs, skipping stones, going for hikes, looking for adventure, finding rocks, playing in the water and "being" at the big lake. Allow plenty of time for these things and don't worry about structure as much as you do at school. One very popular activity is to go to a state park like Gooseberry on Thursday afternoon with no set plan. Divide up into smaller groups, each with an adult, and go off on separate adventures. The groups usually end up near the bottom of the falls with students and sometimes with adults, playing in the water. Just arrange a time to meet in the parking lot for departure.

WHAT TO DO IN CASE OF DISASTER

Trouble does occur on these trips. Groups have been stuck in the William Irvin for several hours during a tornado warning, had no electricity at the campground because of severe storms, had rain for all three days and nights, freezing temperatures, a lost contact lens, a students with only one pair of shoes (with one of them lost in the river), a sprained ankle, a trip to an emergency clinic for a bladder infection, homesickness, loss of stamina, racism in a small Northern Minnesota town, vehicle breakdowns and so much fog that you can't even see the lake for three days! There is only one way to get through these challenges. Maintain the belief that this adventure is worth it, that the group unity and memories gained will remain as highlights of a child's education, and that the lake in its splendor will overcome the negative moments. You will go home feeling exhausted, yet spiritually uplifted. It just takes personal stamina, reliable chaperones, an endless sense of humor and good luck!

Sample letter to participants on field trip to Lake Superior Center and surrounding area

Date

Dear Families,

At last, here is the camping information note!! We are all set to embark on our annual adventure to (location) on (dates). Parents have graciously agreed to drive and act as chaperones. Many thanks to (list the chaperones). We will leave (your school) on (date) at (time) and will return on (date) at (time). You will need to make arrangements to pick up your child in front of the school at that time. The fee this year is going to be $(price). We desperately need every cent of this, so please take this two weeks to save the money. If you can afford a few extra dollars for scholarship funds please enclose it. If you need to request some scholarship help, please enclose whatever you can.

Here is our (sample) itinerary:

Wednesday, June 7
Leave your school at 9:00 AM
Rest stop in Hinckley
Lunch at Canal Park in Duluth
Geology lesson with Lake Superior Center staff member on Park Point
Drive to Split Rock Lighthouse Park and campground
Set up camp
Dinner/campfire/stories

Thursday, June 8
Camp breakfast
Optional morning tour of Split Rock Lighthouse
Lunch
Afternoon trip to Gooseberry Falls State Park
Hiking/dinner/stories

Friday, June 9
Camp breakfast
Break camp and pack
Drive to Duluth
Lunch
Vista Fleet Cruise on the harbor and train ride to Two Harbors (12:30-5:00)
Return to school for pick up at about 8:00 PM
[Telephone number for camping site here]

Sample permission slip for students going on field trip to Lake Superior Center and surrounding area

Your Invitation to Lake Superior for 1995

You must be willing to meet these expectations:

Assurance to parents and (list names of teachers) of cooperation, cheerfulness and acceptance of responsibility for self and belongings at all times.

Parent/guardian gives permission and agrees to be responsible for child in case of illness or emergency.

(*** If your child is taking medication or has any medical problems I should be alerted, so please contact me before the trip. We are fortunate to have a nurse accompanying us this year.)

Agreement to abide by the (school) rules on the camping trip:

I, _____ (student) have talked all these things over with my family at home and agree to the conditions listed.

I, _____ (adult) give permission for the child to camp at the North Shore on (dates) with (names of teachers). I understand that my child will be travelling in private vehicles, will be provided with a seat belt and will be covered by the insurance the school district offers for overnight camping.

If you have any questions, please call me. (List school and home phone numbers)

Permission slips and fees must be turned in by (date).

Teacher's Signature

Things to pack for camping

Please cross each thing off as you pack it so you don't forget anything.

<u>Needed</u>
- plastic plate
- plastic cup (sturdy enough to last for three days and five washings)
- knife, fork, spoon (metal suggested for durability)
- sleeping bag
- pillow
- towel and washcloth
- toothpaste and toothbrush
- soap
- comb or brush
- two (2) pairs of shoes (one always gets wet)

- two (2) pairs of long pants
- one (1) or two (2) short pants
- two (2) shirts
- one (1) or two (2) sweatshirts
- five (5) pairs socks and underwear (extras in case they get wet)
- sweat suit for sleeping
- warm jacket, gloves and hat: it gets cold on the North Shore so be prepared!!!
- rain gear
- two (2) large plastic garbage bags to keep belongings in if it rains
- bag lunch for Wednesday

Optional
- camera
- flashlight
- bug repellent
- snacks for sharing (chips, fruit roll-ups, cookies, etc.) NOT pop or candy
- money for snacks or souvenirs
- bathing suit in case of warm weather
- games or cards
- balls, gloves
- a good book to read

*** Remember, NO electronic devices are allowed

Unit: Lake Superior A to Z

Learn your ABCs and about Lake Superior too! A terrific way to incorporate Lake Superior into the primary classroom!

TOPIC
Lake Superior A to Z.

AUDIENCE
K-3 (some lessons may require adaptation for kindergarten)

LENGTH
Can be condensed into book form or spread out over the school year with a topic a week. Teacher may decide to do a two week unit.

GOAL
To understand how the letters of the alphabet represent/ symbolize aspects of Lake Superior.

OBJECTIVES
- Students will be able to locate Lake Superior on a map and understand the importance of it in our daily lives.
- Students will gain an appreciation for the lake by learning about the physical, cultural, and living parts of the lake.
- Students will learn that Lake Superior is the largest lake in the world by surface area.

MATERIALS
- see individual lessons

BACKGROUND

Lake Superior is ten percent of the world's surface freshwater. It is a unique natural resource to the region, the nations of Canada and the U.S. and the world. Freshwater is a resource which is too precious to take for granted. Paddle-to-the-Sea is a great book to use for many of the letters such as "c" for canoe, "d" for Duluth, "m" for map, "s" for Soo Locks, "g" for Great Lakes, etc. Other potential resource books are listed at the end of the unit.

PROCEDURE

Following are suggestions for working with each letter of the alphabet in building knowledge about and care for Lake Superior. You may choose to introduce Lake Superior A-Z throughout the year or over a specific block of time.

In addition to the given lessons, students can research or be read information related to each letter and then be given the assignment of creating a page which would depict Lake Superior as it relates to their letter. Older students could do a presentation or skit related to the lake.

BEST COPY AVAILABLE

A-Z Introduction

MATERIALS
- A-Z photo cards
- floor map of Lake Superior or tape/chalk outline

GETTING READY

Prepare 26 cards with images of things from A-Z (e.g. A is for Agates, D is for Dogs, F is for Fish, W is for Whales) that do or do not belong in Lake Superior.

PROCEDURE

1. Our Lake Superior home

Unroll a large map or create a tape/chalk outline of Lake Superior on the floor. Get students to orientate themselves to some familiar landmarks like Duluth, Superior, Isle Royale and the North Shore. Discuss that we all have a home and throughout the week or year we will be learning about Lake Superior and its importance as a freshwater home. Brainstorm a list of things that the students know about Lake Superior.

2. Does it belong?

After asking the students to share what they know about Lake Superior, tell them that you are going to give them a little quiz to *really* test their knowledge. Explain that you will show them pictures of things that do or don't belong in Lake Superior. They should say out loud either "yes" or "no" depending on whether or not the item belongs in Lake Superior. Group response works well for this.

Begin showing the pictures to the group. When tricky ones such as whales come up, let the students know it's a tough one. Some, such as dog, are also tricky because although dogs don't live in the lake, they sometimes swim there. Use this activity to lead into discussions about Lake Superior.

To Z from A, The Superior Way

A is for agates, algae, Anishinabe

- Have the students sort AGATES by various categories or by pictures. Older students can pair up and make up categories first, then sort them by those categories. They can then exchange their agates with another group and compare their methods.
- Explain to older students how scientists think agates were created. Hand an agate to each student and have them write a story about how their agate was created and how it might have been found.
- Polish agates that students have found. Have the students look at the shape of the agates and draw the agate's outline before they put them into the tumbler. See if you can recognize your agate when it comes out. How did it change? Tie this in with a discussion or lessons about erosion.
- There are several agate collectors in Minnesota and around Lake Superior. In Duluth, Jim Ramsey, (218)724-7543, will come out to do a presentation and bring samples for

the students to see and touch. Geology has been his hobby for over 40 years.

- The EPA agency in Duluth may be able to come out and do a presentation on ALGAE.
- The ANISHINABE, or Ojibway, have lived in and around Lake Superior for approximately 300 years.

B is for beaches, bridges, bloodworms

- Take a trip to the BEACH. Have a naturalist come out and discuss the formation, plant life, rocks, etc.
- Study a BRIDGE in your area, like the Aerial Lift Bridge in Duluth or the Lift Bridge in Houghton/Hancock. Have students build their own bridges using toothpicks, Popsicle sticks, straws, blocks or some other building material. Parent volunteers would be helpful to younger students. Put up a number of different bridge pictures showing various structures and building materials. Students can use these for inspiration in their own building efforts.
- The EPA's Water Quality Lab in Duluth has speakers that may be able to come out and discuss BLOODWORM indicators and their importance to the lake. Contact Marna Butler-Fasteland at 720-5745.

C is for Coast Guard, citizen, canoe, caribou

- Have the COAST GUARD send a speaker out to your room. They can discuss their job and bring the book, *Officer Snook*, which relates to our job as citizens/stewards of the water. They may also show the students a large map of Lake Superior with the navigational keys. There are branches of the U.S. Coast Guard in Duluth and Marquette; the Canadian Coast Guard is based in Thunder Bay.
- As CITIZENS, we have a great deal to do with the health of Lake Superior. Discuss types of pollution and contamination in the lake as well as things people do to keep the lake clean. Have students color a happy lake and what makes it happy, and draw a sad lake and what makes it sad.
- Would you take a CANOE for a trip on Lake Superior? Why or why not?
- What's a CARIBOU? And why do they live on the far north shore of Lake Superior?

D is for dunes, Duluth

- Take a trip to a beach with DUNES. Pictured Rocks National Lakeshore in Michigan has fantastic sand dunes.
- Take a trip into DULUTH. The Lakewalk is great for primary student field trips.

E is for exotic species, eagle, estuary

- The term "EXOTICS" can be brought up at this time. Use the literature available from the Departments of Natural Resources and Sea Grants. There are numerous exotic species such as the ruffe, the lamprey or the spiny water flea which could be studied. Another option is to list exotic species and related information on this page of the alphabet book. These can also be covered under Z for zebra mussels.
- How does the EAGLE fit into the Lake Superior food chain? (It's a top predator, like people.) The eagle was an endangered species, but has come back and is now found all around Lake Superior.

- Take a trip on the St. Louis River harbor: is it a river or a lake? Actually, it's both. The mixing zone between a river and a lake or ocean is called an ESTUARY, and it's a very important part of the lake habitat, especially for nesting birds and fish spawning.

F is for fish and food chain, ferries

- Try "Lake Superior Circle of Life," in *The Living Lake Superior.*
- Try "FOOD CHAIN Tag" in *The Living Lake Superior.*
- Take a FERRY ride to Madeline Island, Grand Island or even Isle Royale!

G is for geology, glaciers, Great Lakes

- Try "A Bucket Full of Stories" in *The Physical Lake Superior.*
- A speaker from Lake Superior Center may be available to come out and actively involve the students in learning about the evolution of the lake. What role did GLACIERS play in its history? What is a glacier?
- Read *Paddle-to-the-Sea* for older students to see how Lake Superior relates to the other GREAT LAKES.

H is for harbor and hatchery

- A trip aboard the Vista Fleet in the Duluth HARBOR or other harbor tours is a first-hand approach to learning about harbors. Students can play "Lake Superior Bingo" while on board.
- Take a trip to a HATCHERY or have a DNR representative come out to your classroom.

I is for islands, Isle Royale, ice

- How many ISLANDS are there on Lake Superior? Get out a map and try to count (over 1400!).
- *Once Upon an Isle,* by Howard Sivertson, provides good historical stories for older students and is also a useful source for background information and pictures of life on ISLE ROYALE.
- When is there ICE on Lake Superior? Does it freeze over like other lakes? No–it only freezes over every 15 years or so. Why? Because it's so big. Label a large pail of water "Lake Superior" and a small cup of water "Bob's Pond" and put them in the freezer for two or three hours. Which one freezes? Why doesn't the big one freeze all the way?

J is for jobs

- What kinds of JOBS do people have that are related to the lake? Invite local people in the tourism, shipping, fishing, mining, timber, paper or education fields to come and share how Lake Superior affects their jobs and how their jobs affect Lake Superior.

K is for kayak, Keweenaw Peninsula

- Have a speaker give a KAYAK demonstration in your classroom. Students can sit in the kayak and feel what it would be like to paddle one.
- Where is the KEWEENAW Peninsula? What is its history?

L is for lighthouse

- How does a LIGHTHOUSE work? Bring out: a lantern with flat wick, reflector and candle, prism and bulb, electric light and matches with candle (be sure to have a fire extinguisher and bucket of water on hand!). Bring out the illuminating objects one at a time. Ask students to help you arrange them in order of how much light they give off. Light

each one and then turn off the overhead lights. Put numbers by their choices. Which would you use to light your lighthouse?

- Read *Beacons of Light: Lighthouses,* by Gail Gibbons, to the students. Tell them to listen carefully to the book to see which lights have been used in lighthouses and which ones worked best. The book talks about the lighthouse keeper. Show students the lantern with a wick. Discuss the lighthouse keeper's job. Are keepers needed today? Also, how did the arrangement of the lights in the previous activity compare with the history of lighthouse lights in the book? Which lights weren't in the classroom sample but were mentioned in the book?
- Show pictures of several Lake Superior lighthouses to them and discuss why lighthouses were built and how they are used today. Fog horns can also be discussed.
- Have the students design their own lighthouse to warn ships about rocks and fog. Once they have drawn the outline, have them color it.

EXTENSIONS

- The U.S. Postal Service issued a set of stamps entitled "Lighthouses of the Great Lakes" in the latter part of 1995. Looking at these may be interesting to students.
- other word ideas: LOON, LAMPREY.

M is for map, minnows

- Compare the outline of a MAP of Lake Superior with a wolf's head. Put up an enlarged outline of Lake Superior. Ask students if they recognize which lake it is. Show them how the shape of Lake Superior is special because it resembles a wolf's head. Quickly sketch in the nose (sniffing Duluth-Superior), the left eye (Isle Royale), the ears (Black Bay and Nipigon Bay), the open mouth (Keweenaw Peninsula), whisker sites (Apostle Islands) and the head shape (the rest of Lake Superior).

  Compare your quick drawing with the actual picture of a wolf's head. Have the students color their own wolves on the outline maps you pass out to them. Older students may, in addition, be able to label cities or islands that coordinate with parts of the wolf.
- Have a bait shop come out and discuss the role MINNOWS and small fish play in the Great Lakes food web.

N is for navigation

- The Coast Guard or Power Squadron could come to speak about NAVIGATION.

O is for otter

- Try "You OTTER Be There" from *The Living Lake Superior.*

P is for points, pier, port

- Explore PARK POINT, Minnesota; Whitefish POINT, Michigan; Long Island, Wisconsin; or other natural sand bars on the lake.
- Is there a PIER nearby?
- How could Duluth and Thunder Bay be "world PORTS"? Trace the connection with the world through the Great Lakes.

Q is for quiet

- Talk about being on the lake during a calm, QUIET day or night, going to

a remote spot or just being away from other people.

R is for rainbow trout

- Read *The Rainbow Fish,* by Marcus Pfister, to the class. Put up outlines of both the Rainbow Fish from the book and the RAINBOW TROUT. We have a real rainbow fish in Lake Superior, but it is quite different from the one in the book. Put up transparencies or outlines of the two fish. Ask the students to compare the shape and color of the Rainbow Fish with that of a real rainbow trout. What are the differences? List them on the board if the students can read, if they are pre-readers, make arrows pointing to what the students say.
- Share the information that some fish have been added to Lake Superior just for fishing. They would not be in the lake if people didn't put them there. The rainbow trout is one of those fish. It was brought to Lake Superior in 1895 from the Pacific Ocean. In Lake Superior, it's called the "steelhead."
- Have students find other fish that were introduced to Lake Superior. Add them to the map and show where they came from. Students may be interested in finding out how so many ocean fish, such as salmon, can survive in Lake Superior. If you have them add fish such as the Eurasian ruffe, you will need a world map. Have students make a chart showing the fish name, place of origin and method of introduction (also tell if it was an intentional or unintentional introduction). Place the chart next to the map.
- Sing RAIN songs.
- Where's the nearest RIVER? Does it flow into Lake Superior?

S is for ship, sand, storm, shipwrecks, salmon, Soo Locks and Sault Ste. Marie, sturgeon

- Discuss the parts of a SHIP and color a picture of a ship. Discuss the types of cargo hauled on Lake Superior ships. Go to a marine museum like the one in Duluth.
- Make a Lake Superior STORM in the classroom, with sounds and waves (see "Making Waves" in *The Physical Lake Superior*). What do storms have to do with SHIP-WRECKS?
- Construct lock models out of milk cartons. Read the section in *Paddle-to-the-Sea* where Paddle goes through the SOO LOCKS.
- Play the song "Wreck of the Edmund Fitzgerald." This is about a ship in a storm on Superior that was headed for the Soo.

T is for tugboat, Thunder Bay, tourist

- Read the book *Little Toot,* by Hardie Gramatky, to the students. Discuss the uses of TUGBOATS on Lake Superior (for maneuvering the saltwater ships in the harbors, for hauling or pushing things such as work docks and dredges).
- Show a picture or pictures of various tugs on Lake Superior. Talk about the parts of the tugs and about the likenesses and differences between them.
- Have the students trace around their shoe onto a piece of paper. They can use the tracing to help them draw and color a tugboat (the pilot house and stack are actually drawn on top of the shoe outline rather than in it).
- Arrange a trip to tour one of the working tugboats in a harbor near

you (like THUNDER BAY!); there are also historic tugs such as the "Edna G." in Two Harbors, Minnesota.

- Discuss what the word TOURIST means and how tourists help or hinder an area.

U is for underwater

- Line students up along a long sheet of butcher paper. Have the students create a Lake Superior aquarium for your room with their crayons or markers. You may want to distribute sheets showing Lake Superior creatures on it. Remind the students that an aquarium shows UNDERWATER life. When they finish coloring put the paper up on the wall and cover the pictures with a long strip of blue or green plastic wrap to simulate an aquarium.
- Make your whole room into an underwater world. Place blue plastic wrap on the ceiling, a dark bottom outline of a boat and underside views of fish. Hang a fish hook (made of aluminum foil) and fish down from the ceiling. Decorate the walls with fish and plants. Play underwater sounds in your room during free times.
- Set up a freshwater aquarium in your room. Ask the DNR about fish you could use; some freshwater fish, if collected from the wild, require permits. It is always important to remember never to release aquarium animals into the wild, neither native or non-native species.

V is for volume, Voyageur

- Do the activity "All the Water in the World" in *The Physical Lake Superior* to show how the VOLUME of Lake Superior compares to the volume of other water bodies in the world.
- Learn and sing simple VOYAGEUR songs. Some short stories from *The Illustrated Voyageur,* by Howard Sivertson, may also be appropriate.

W is for waves, Witch Tree, wind, weather, walleye, William Irvin, windsurf, watershed

- Try the activity "Making WAVES" in *The Physical Lake Superior.*
- Visit the WILLIAM A. IRVIN in Duluth.
- Make a model of the Lake Superior WATERSHED. Have students pour water in different areas of the model, guessing beforehand where they will end up.
- Hartley Nature Center in Duluth offers activities on pond life and water quality.

X is for eXcellent spot to live!

- What makes Lake Superior so great?

Y is for yacht, you

- What is YOUR role in the Lake Superior system?
- What is your favorite thing about Lake Superior?
- What can you do to maintain or improve Lake Superior?

Z is for zebra mussel

- Give each student a handful of ZEBRA MUSSELS but don't tell them the name. Tell them only that the shells are found in North America but they were imported or brought from a different part of the world. These shells are just the outside part of the animal. The animal is no longer inside the shell.

Have the students brainstorm a list of names they might use for these shells/animals.

Their list of name ideas will probably be wonderful, but ask them if they would like to know what people really call these animals. They are called zebra mussels. How do you think they got their name? Stress the striping on the shell and the fact that like zebras, zebra mussels are also foreign here.

Have the students create their own Lake Superior animal, fish or plant and give it a name.

- Try "Zebra Mussel Mania" in *The Living Lake Superior.*
- Read the *Zebra Mussel* puppet story.

ASSESSMENT (FOR A-Z)

- Create a classroom book with a page for each letter.
- Put together a play.
- A bulletin board can be created to symbolize the unit. "Lake Superior Our Freshwater Home." "A to Z; Agates to Zebra Mussels."

REFERENCES

* Denotes books students may enjoy reading or hearing. Other books listed could be adapted or used as teacher references.

A

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*Cooper, Jason. *Bridges.*

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*Yagelski, Robert. *The Day the Lifting Bridge Stuck.*

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*Sivertson, Howard. *The Illustrated Voyageur.*

D

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E

Minnesota Department of Natural Resources. *A Field Guide to Aquatic Exotic Plants and Animals (pamphlet).*

*Gieck, Charlene. *Bald Eagle Magic for Kids.*

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Downs, Warren. *Fish of Lake Superior.*

Lagler, K.F. and Goldman, C.R. *Fishes of Isle Royale.*

*Parker, Steve. *Fish* (Eyewitness Books).

Zim, Gerbert S. and Shoemaker, Hurst H. *Fishes: A Guide to Fresh- and Salt-Water Species*

G

Baylor, Byrd. *Everybody Needs a Rock.*

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Pough, Frederick H. *Peterson First Guide to Rocks and Minerals.*

H

Crews, Donald. *Harbor.*

Maestro, Betsy. *Big City Port.*

I

Holden, Thom. *Above and Below.*

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*Sivertson, Howard. *Once Upon an Isle.*

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L

*Behrens, June. *Lighthouse Family.*

*Cooper, Jason. *Lighthouses.*

*Gibbons, Gail. *Beacons of Light: Lighthouses.*

Hall, Stephen P. *Split Rock: Epoch of a Lighthouse.*

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*Roop, Peter. *Keep the Lights Burning, Abbie.*

Sandvik, Glenn N. *A Superior Beacon.*

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Blakely, Roger and Truesdale, Hardie. *North from Duluth.*

Murray, John. *Lake Superior, Wow!*

Waters, Thomas F. *The Superior North Shore.*

O

*Allen, Laura Jean. *Ottie and the Star.*

*Arnosky, Jim. *Otters Under Water.*

Hazard, Evan B. *The Mammals of Minnesota.*

Le Lievre, Roger. *Know Your Ships.*

*Robinson, Sandra Chisholm. *Sea Otter River Otter.*

*Tompert, Ann. *Fun for Ozzie.*

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R

*Pfister, Marcus. *The Rainbow Fish.*

*Symes, Dr. R. F. *Rocks and Minerals* (Eyewitness Books).

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*Baily, Donna. *Ships.*

Manse, Thomas. *The Soo Locks.*

T

*Burke, Timothy R. *Tugboats in Action.*

*Gramatky, Hardie. *Little Toot.*

*Gramatky-Smith, Linda. *Little Toot.*

*Lasky, Kathryn. *Tugboats Never Sleep.*

U

V

Nute, Grace Lee. *The Voyageur and The Voyageur's Hiway.*

*Sivertson, Howard. *The Illustrated Voyageur.*

Wheeler, Robert C. *Voices from the Rapids.*

W

*Swallow, Su. *Starting Points—Water.*

X

Y

Z

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PUPPETS NEEDED
- *Sam the Clam*
- *Zebra mussels to add on to Sam*
- *Snappy the Crayfish*

Zebra Mussel Story

Sam (In a whisper and looking around)

"Hi there. You can call me Samantha or Sam for short. Can you guess what I am? That's right, I'm a clam. I live in the St. Louis River, the one that runs into Lake Superior between Duluth, MN and Superior, WI. Oh no! Here they come! Can you see them? No I don't suppose you can, they're just veligers, or free-swimming larvae right now, too small for you to see, but just wait."

(Take puppet behind a curtain or barrier and add the zebra mussel shells onto the clam's shell at each velcro site)

"Now can you see them? Time has passed and they've grown bigger, so big and so many that I can hardly feed myself. They're growing all over the edge of my shell where I open up. That's the place where I take in water so I can filter my food out of it. You see I can't run away from these zebra mussels because I have no way to move. Look! I notice my neighbor couldn't move fast enough either."

Snappy

(Bring in the crayfish with the other hand. It should already have zebra mussels attached to its body)

"Hey Sam. I see you and I are having the same luck lately. These zebra mussels are ruthless. You don't move fast enough and they grow all over you. Can you believe the nerve! Who do they think they are? I hear from the sunfish that these zebra mussels aren't even from these parts. People brought them over from some place called Russia."

Sam

"What a crazy idea that was, Snappy!"

Snappy

"Well I hear they think so too. You see these mussels are now growing on their boats, docks, water intake pipes, and any other flat surface underwater. It's been expensive for them and it's not a problem that's going away."

Sam

"So why did they do it?"

Snappy

"The muskrat told me it was an accident. She said the zebra mussels came over in the ships' ballast water. They used to fill the ship with water from where they came from and then dump it in our harbor. The water helps the ship ride better across the ocean. Anyway, although the zebra mussels couldn't survive the trip, the eggs and young could. All an accident. Can you believe it?!"

Sam
"Well there's nothing we can do about it is there. I sure hope those humans realize what a hard time we're having down here. Then they might do something to help us."

Snappy
"But how could they help??"

(Good question! How can the humans help?)

Cleaner Streets, Cleaner Waters Preview

GRADE LEVEL
6-10

SUBJECTS
Science, language arts.

SKILLS
Observation, investigation, analysis, presentation, listening, teamwork, language arts, problem solving, creative and interdisciplinary thinking.

LENGTH
Eight 45-55 minute classes/lab sessions, and half- to whole-day of field learning.

SETTING
Indoor and outdoor

Cleaner Streets, Cleaner Waters

A module for learning about storm runoff and water pollution in the Lake Superior basin and a guide for student leadership in community pollution prevention activities.

Available now from Lake Superior Center!

How do you involve your students in active protection of Lake Superior? In the big world of lake protection, what can one student or group of students really do?

"Cleaner Streets, Cleaner Waters" is for use by teachers and leaders of groups of youth who are in grades six through ten and reside within the Lake Superior watershed. "Cleaner Streets, Cleaner Waters" consists of two parts. Part I is an interdisciplinary, supplemental, environmental education module about urban storm runoff and water pollution in the Lake Superior basin. Part II provides ideas for student leadership in community pollution prevention activities.

"Cleaner Streets, Cleaner Waters" is developed from the work of Kerry Hicks, a Lake Superior Center Freshwater Fellow, and is being produced by the Wisconsin Department of Natural Resources. The final project is available from the Lake Superior Center; contact the center for your copy.

What do clean streets have to do with Lake Superior?

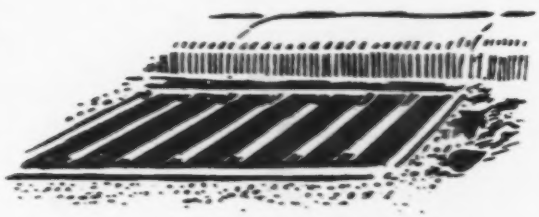
Keeping our precious water resources clean has been a focus of communities, businesses, individuals and governments for many years. As a society we have had great success in dealing with pollution from factories, city sewers and other identifiable sources of pollution. Now the attention of these same communities, businesses, individuals and governments is turning to more indirect but equally harmful sources of water pollution. This "non-point" source pollution is the impact of many small individual actions, like spilling motor oil in the drain, spraying pesticides on the yard or driving an automobile.

How these non-point source pollutants reach our waterways is where the stormwater story begins. Although we live in an increasingly urbanized society—developed and paved—the water that comes from rain or snow still must flow somewhere. When it flows through areas that have been altered by humans, it will be affected by that human presence on the land. Stormwater carries away much of the contaminants that we have purposefully or inadvertently spread on the land to streams and rivers and larger bodies of water—such as Lake Superior.

The problem is well documented. The Lake Superior Binational Program monitored runoff in 11 urban areas along the United States shores of Lake Superior in 1993-1995. They found 49 pollutants headed for Lake Supe-

rior, many of them in quantities exceeding standards set to protect public health and the environment. The findings were generally consistent with studies of urban runoff in other cities of the Midwest, and throughout the United States and Canada.

The solution possibilities are many, including erosion control ordinances as well as state and provincial permits that require certain developers to have and follow through on plans to minimize storm water pollution. State agencies, cities and many developers are doing a lot, yet there is much more to do. Well-informed students can take the lead in their communities by generating public awareness and by showing others what they can do to prevent pollution at home, at work and at play.



TOPIC
Limnology.

AUDIENCE
Grades 9-12, 15-30 students

LENGTH
The six lessons can be spread out over about two weeks.

UNIT GOAL
Students will understand that lake water quality is the result of complex interactions between the physical, chemical and biological elements of the lake.

MATERIALS
- *raw data of Lake Superior research (included)*
- *research materials including books, brochures and videos*
- *Lake Characteristic Cards (included)*
- *Lake Superior map*
- *western end of Lake Superior map*
- *Duluth-Superior harbor map*
- *thermometer*
- *Secchi disk*
- *dissolved oxygen kit*
- *pH kit*
- *alkalinity kit*
- *water sampler*
- *water jug*
- *waste disposal bottle*
- *first aid kit*
- *PFDs*
- *depth meter*
- *clipboards*
- *plankton net*
- *microscopes*
- *organisms for artificial lake experiment—contact Environmental Protection Agency*
- *potassium phosphate and sodium nitrate for nutrient stock solution recipes.*

Unit: What is a Lake?

Investigating the biological, chemical and physical nature of a lake.

ACTIVITY 1—Introduction to Lake Terminology and Processes
ACTIVITY 2—Create an Artificial Lake
ACTIVITY 3—Group Research
ACTIVITY 4—Use of Sampling Equipment
ACTIVITY 5—Lake Sampling
ACTIVITY 6—Analyzing the Data, Writing the Report and Presenting the Results

This unit is an introduction to the scientific study of lakes, especially Lake Superior. The six lessons emphasize a step-by-step approach, in which each day's accomplishments connect to the next day's activities. The unit is intended for high school students, although it can be adapted for younger audiences. Most materials needed for this unit are available in the Lake Superior Ecosystem Learning Kit.

Access to a boat or pier for water sampling is the desired method of data collection. Raw data will be available for those classrooms that are not able to sample outdoors and for those classrooms that would like to compare their results to other data.

INTRODUCTION

What is a lake? Often, answering complex questions requires viewing the whole as a collection of its parts. Thus, to understand more about the big picture, in this case the whole lake, we divide it into several categories and study each part separately.

The parts can be classified into three categories: physical, chemical and biological. The physical nature of a lake concerns factors such as the basin's depth, shape, water movements and the distribution of light and heat. In comparison, the chemical nature concerns the distribution of nutrients, dissolved oxygen and carbon dioxide and pH. Lastly, the biological nature focuses on the type, abundance and distribution of living organisms within the lake.

A lake is a dynamic mixture in which all the different parts interact and influence each other. Simply stated, the biology, or life within the lake, is a product of the lake's physical and chemical nature. The opposite is also true, since organisms within the lake manipulate its chemical and physical properties.

For example, a byproduct of photosynthesis by aquatic plants is dissolved oxygen. Aquatic animals and plants use dissolved oxygen to respire and in turn give off carbon dioxide as a byproduct of their respiration. That carbon dioxide can then

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be used by plants for photosynthesis. If there is a physical restriction, such as during summer lake stratification when epilimnetic and hypolimnetic (see lake characteristic cards) waters do not mix, the bottom waters are cut off from the replenishing atmosphere.

When a lake is stratified, the thermally divided sections often contain different types and quantities of animals and plants. These conditions can create higher dissolved oxygen levels in the upper waters, in comparison with bottom waters, which may be saturated with carbon dioxide. Because of the need for oxygen for respiration and carbon dioxide for photosynthesis, these chemical differences determine the type of organisms which can exist in each section. So in effect, the chemical differences, created by biological differences, as a result of physical barriers, will influence the type of organisms which can survive in each section of the lake.

To add to this, there are several other physical and chemical factors such as distribution of light, pH and nutrients which also directly effect the types and quantities of organisms which can survive and flourish in an environment. Finally, the interactions between organisms, such as competition and predation, also dictate the biological, chemical and physical nature of the lake. Clearly, a lake's water quality (its trophic status) is the result of complex interactions between abiotic and biotic factors which exist in a marvelous web of direct and indirect connections.

This lesson introduces students to some of the factors which influence a lake's water quality. The focus is on basic lake functioning. Some water quality problems such as toxic pollution are not directly sampled or studied, though this lesson provides an excellent transition into a study of why toxic pollutants are such a problem in aquatic ecosystems.

A step-by-step reductionist approach is applied in this lesson. Students begin by learning and understanding lake classification and terminology. After this introduction they proceed to create artificial lake environments in mason jars or aquariums. The rest of the lesson focuses on actual lake sampling. To improve efficiency and foster independence, the class will be split into six groups, or research teams. Each team will perform initial research, learn how to use the sampling equipment, prepare data sheets, collect data, analyze the data they collected in written papers with graphics and present their results orally. Once all the groups have presented their individual topics, the pieces can be recombined and the whole lake can be envisioned.

Introduction to Lake Terminology and Processes

(ACTIVITY ONE OF "WHAT IS A LAKE?")

Students are placed into groups to learn about different parts of lakes, as well as different types of lakes.

TOPIC
An introduction to the terminology used to describe lakes.

LENGTH
One or two 45-60 minute class periods

GOAL
To learn about lake zones and lake types, and understand the diversity of a lake as a habitat.

OBJECTIVES
- Students will work in groups and create a poster which explains a specific lake zone or lake type.
- Students will use the poster they created to present their topic to the rest of the class.

MATERIALS
- 5 large pieces of paper or posterboard
- markers
- lake characteristic cards

BACKGROUND

Lakes have a birth, life and death. The trophic state is a description of where a lake is in its life cycle. Often the trophic state index is used to measure water quality. The trophic state index defines three states (see chart below).

Lake Superior is approximately 10,000 years old and is an oligotrophic lake. Several factors combine to make Lake Superior oligotrophic. The lake has a low nutrient level, very cold water and relatively few people living in the watershed. The low temperature and low nutrients discourage plant growth needed to sustain animal growth. Because of the low amount of plant and animal life in the lake, the water column is very transparent.

Many smaller inland lakes in Minnesota and Wisconsin are mesotrophic or eutrophic. These lakes tend to have lots of nutrients and abundant plant and animal life. The water column is less transparent and warmer than Lake Superior.

Many of the lakes in the Great Lakes region are "dimictic." Dimictic lakes have two mixing periods a year. One mixing period is in the fall, one is in the spring. When the lake is stratified the warm surface water has a lower density than the cold bottom. When surface water drops below 4 degrees Celsius, the point of highest density of water, the lake mixes. In the spring the surface layers warm up and the lake mixes again. In the summer the lake will stratify as surface waters warm. This mixing process distributes oxygen and nutrients throughout the whole water column. Lake Superior is unusual because it often continues to mix through the winter after the initial turnover in the fall. This occurs because the lake does not usually ice over completely.

1. Oligotrophy
- new lakes with low nutrients
- little plant and animal life
- abundant oxygen
- very transparent water column

2. Mesotrophy
- mid-aged lake
- between oligotrophy and eutrophy

3. Eutrophy
- abundant nutrients
- lots of plant and animal life
- sometimes depleted of oxygen
- low transparency in water column

The two main nutrients in a lake that affect eutrophication are phosphorus and nitrogen. Phosphorus is supplied to the lake mainly through weathering of igneous and sedimentary rocks, human and animal waste, laundry detergents and the decay of plants and animals. Nitrogen is very abundant in the atmosphere, though in a form which cannot be used by directly by organisms. Some nitrogen enters the lake in a form plants can use (nitrate or ammonia) via rainwater, and some is converted to a useable form by a few select groups of bacteria in the lake. Nitrogen is also a waste product of animals and is in higher concentrations on the bottom of the lake because of decomposing plant and animal materials.

There is a wide variety of living creatures in lakes. A general list of organisms includes: viruses, bacteria, cyanobacteria, fungi, algae, aquatic macrophytes, protozoans, crustaceans, rotifers, aquatic insects, worms, mollusks, fish, birds and mammals. Each of the lake regions or zones functions as a sub-habitat and hosts its own biological community. For example, there is a shallow water or "littoral" community, an open water or "limnetic" community and a bottom or "benthic" community. Some organisms such as fish, which are capable of efficient, directed movement, are members of several different communities.

The food chain in Lake Superior and other lakes is based on the microscopic, free-floating, autotrophic phytoplankton, and their abundance is based mainly on nutrient concentration, water temperature and grazing pressure. Zooplankton (microscopic animals like Daphnia) eat the phytoplankton. Zooplankton are fed upon by small fish, which in turn are eaten by large fish. Various mammal and bird species feed on the large fish. Bacteria decompose dead animals to the nutrients of which they are composed and the phytoplankton then use those nutrients for growth.

PROCEDURE

1. Introduce topic

Explain that one goal of the lake study is to determine the water quality or trophic status of the lake. Three possibilities exist: oligotrophic, mesotrophic or eutrophic.

Begin the lake study by talking about how the class is going to conduct the research. At least three possibilities exist: sample Lake Superior by boat or along a pier, sample an inland lake by boat or pier or use the existing data set.

2. Student background research on lake processes

Divide the class into five groups. Each group should be given a large piece of paper or posterboard, markers and a lake characteristic card. The group should draw a cross sectional view of a lake representing all of the information on their card. Students should also decide how the chemical and physical characteristics will determine the kind of organisms which live in their lake zone or lake type. Each group should present their drawing and explanation to the class.

EXTENSIONS

- Additional groups can be added to this activity to represent lake succession.
- Students can draw characteristics of a bog, swamp or marsh.
- Students can characterize Lake Superior versus an inland lake, or a river versus a lake.

REFERENCES

Refer to any limnology textbook.

Lake Characteristic Cards

Group One: Lake Bottom Zones

LITTORAL

- shallow shore region affected by waves and ice
- weeds rooted on the bottom
- lots of light and oxygen

PROFUNDAL ZONE

- bottom of the lake lacking weeds
- currents are low
- very reduced light
- low or depleted oxygen
- uniform temperature
- methane and carbon dioxide abundant
- low pH because of presence of carbonic acid
- decaying matter

Group Two: Open Water Zones

EPILIMNION

- open water zone beyond the pond weeds
- plankton habitat containing free-floating plants and animals
- lots of photosynthetic algae
- lots of light and oxygen
- water column mixed by the wind

HYPOLIMNION

- lack of light
- lack of photosynthesis
- respiration and decomposition predominate

Group Three: Oligotrophic Lake

- a new lake with low nutrients
- little plant and animal life
- abundant oxygen
- very transparent water column

Group Four: Mesotrophic Lake

- intermediate level of nutrients
- intermediate level of plant and animal life
- intermediate level of oxygen
- intermediate transparency in water column

Group Five: Eutrophic Lake

- abundant nutrients
- lots of plant and animal life
- sometimes depleted of oxygen
- limited transparency in water column

Create an Artificial Lake

(ACTIVITY TWO OF THE "WHAT'S A LAKE?" UNIT)

In this introduction to some of the essential ingredients (chemical, physical and biological factors) of a lake, students use mason jars or aquariums to create artificial lakes—then they study the effect of nutrient concentration on biology.

TOPIC
Studying a lake in the classroom.

LENGTH
Set-up in one hour, observe for 1-2 weeks.

GOAL
To concentrate on smaller, simplified lake systems which facilitate the understanding of specific lake functions.

OBJECTIVES
- *Students will study the effect of nutrients on the population size of the algal community in lakes.*
- *Students will understand that chemical, physical and biological processes are interdependent*

MATERIALS
- *4 mason jars or 1 liter beakers*
- *Lake Superior water **
- *nitrogen stock solution **
- *phosphorous stock solution **
- *algae sample (Selenastrum) **
- *Daphnia **

** See recipe below for amounts*

PROCEDURE

1. Students set up "lakes"

Have each work group fill 4 mason jars or beakers with water (1 quart jars or 1 liter beakers work well). Following the nutrient recipes shown below, add 1 milliliter of nitrogen stock solution per one liter of Lake Superior water to the first jar, one milliliter of phosphorus stock solution per one liter of Lake Superior water to the second jar and 1/2 milliliter of nitrogen stock solution and 1/2 milliliter of phosphorus stock solution per liter of Lake Superior water to the third jar; the fourth jar will be a control with no nutrients.

Add at least one milliliter sample of algae to each jar, *Selenastrum* work well, and 10 Daphnia to each of the jars. Place plastic wrap over the jars and punch a few small holes in the plastic wrap.

2. Start observations

Place the jars in a warm window and observe daily. The Daphnia will multiply within a few days. You may want to lightly shake jars or mix aquariums with a bubbler to simulate a mixing water column. Continue observations for at least one week.

EXTENSIONS

This exercise could be expanded quite easily using an aquarium. Both complexity of the system being studied as well as observation time could be effected. One way this could be done is to collect organisms when the class is sampling the lake. You do need permission to harvest some live organisms, therefore it would be wise to contact the DNR or other regulatory agencies to find out the details and ask for permission.

REFERENCES

Suggestions on setting up and maintaining a freshwater aquarium are available from several sources including: *The Fascinating Freshwater Fish Book*, by John R. Quinn.

	Nutrient	Algae	Zoo-plankton
Jar 1	1 ml Nitrogen stock solution/liter of lake water	1 ml	10 Daphnia
Jar 2	1 ml Phosphorus stock solution/liter of lake water	1 ml	10 Daphnia
Jar 3	1/2 ml Phosphorus & 1/2 ml nitrogen/1 liter lake water	1 ml	10 Daphnia
Jar 4	1 liter of lake water	1 ml	10 Daphnia

Nutrient Recipes

Nitrogen Stock Solution	85.0 grams of sodium nitrate per liter of Lake Superior water
Phosphorus Stock Solution	8.7 grams of potassium phosphate per liter of Lake Superior water

Group Research

(ACTIVITY THREE OF THE "WHAT IS A LAKE?" UNIT)

Students will participate in a group research project using materials available from either the Lake Superior Ecosystem Learning Kit or other sources.

TOPIC
During the first stage of the sampling project, students receive and study research topics.

LENGTH
One or more class periods

GOAL
To understand a particular research topic and how research will be conducted.

OBJECTIVES
- *Students will understand their research topic.*
- *Students will be able to demonstrate that their research topic is an important part of understanding the whole lake.*
- *Students will be able to explain the relationship between overall water quality and their research topic.*
- *Students will recognize the need for well planned research.*

MATERIALS
- *Group Assignments (see next page)*
- *map of Lake Superior (or other lake) sampling area*

PROCEDURE

1. Set up work groups

Students should be placed into groups for the lake study. Each group will be responsible for researching their topic. Students will find materials for research in the Lake Superior Ecosystem Kit. Each group should be given instructions concerning what they will research and how they should sample the lake.

2. Start research

Students should be given the hour to work in their groups.

Lake Study

As a class we are going to study the chemical, biological and physical aspects that determine lake water quality. Students will be divided into 6 groups. Each group will be researching a different topic related to the trophic state of the lake. The class will be going to a lake to take water samples. A day will be spent analyzing the results and the last day will be spent presenting each group's results to the class as a whole.

Each group will be responsible for the following tasks:

1. Learning how to test for the topic being studied.
2. Sampling at the lake.
3. Filling out a data sheet at the lake.
4. Graphing all results and providing a table with all data.
5. Turning in a group research paper that includes all research, data, graphs and results for your topic.
6. Presenting all results to the class orally.

Have fun and good luck!

GROUP ASSIGNMENTS

Group One: Lake Topography and History

Group One will need to obtain a map of the lake and adjust the sampling area to size so that it will fit on a 8.5 by 11 inch sheet of paper. The map must include the outline of the lake, depth soundings, the deepest location and the sampling site.

The sampling site will be selected by group one and determined by the depth and accessibility of the site. Group One may also add locations of possible sources of pollution, locations of building sites, drain pipes, roads or any other information they would like to include on their map of the lake and/or surrounding area. Group One will also be responsible for researching and providing a geological description of the lake formation.

While at the lake, group one will determine the location of the sampling site. A data sheet should be filled out that describes the general topography of the lake and surrounding area. For example, does the land around the lake have steep banks, or is it in a flat or rolling area? Do you think the lake receives a lot of wind which might aid in mixing the water? Look around the lake for any other observations that could be included in your research paper.

Group One will also collect data concerning the weather conditions on the date of the lake study.

Group Two: Temperature Profile

Group Two will be responsible for measuring the temperature at each meter of depth at the sampling site. A data sheet will need to be filled out at the lake. This data should then be transferred onto a graph with temperature on the x axis and depth on the y axis (see examples in "Superior Lakewatch" lesson or a limnology textbook). The epilimnion, metalimnion, hypolimnion and thermocline should be labeled on this graph. A hypothesis should be made prior to the lake sampling. The hypothesis should state whether the lake is mixed, stratified or somewhere between these two states.

The research paper should contain information about how the epilimnion, metalimnion, hypolimnion and thermocline were determined and what they mean. The paper should also talk about dimictic lakes and the reasons why lakes stratify and mix throughout the year in this part of the country. This information can be worked into any or all parts of the research paper.

Group Three: Light Transparency

Group Three will be responsible for taking several Secchi disk readings and averaging the results. To take a Secchi reading, the observer lowers the disk into the water until the disk can no longer be seen, and then raises it just enough so it comes into view again. The depth at reappearance is the Secchi reading; estimate the reading to the nearest one-half foot. This depth should be entered on a graph with depth on the y-axis and all trials of the Secchi disk on the x-axis.

Research should include information about why the depth at which the Secchi disk disappears is significant.

For instance, the Secchi depth can be used to determine the trophic state index (TSI). The TSI can be determined with the following formula:

$$\text{Trophic State Index } TSI = 10\left(6 - \frac{\ln SD}{\ln 2}\right)$$

SD is the Secchi disk reading in meters; "ln" is the natural log.

A lake is considered oligotrophic if the TSI is between 0 and 40, mesotrophic if the TSI is between 40 and 60 and eutrophic if the TSI is greater than 60. A hypothesis should be made considering which trophic state the group thinks the lake will fall into before the study. The results should also include general information about the definition of each of the three trophic states.

Group Four: Dissolved Oxygen

Group Four will be responsible for testing the dissolved oxygen at each meter of depth at the sampling site. All data should be placed on a graph with the mg/L of dissolved oxygen on the x-axis and the depth on the y-axis. All information should also be placed in a readable table.

A hypothesis should be made concerning whether there will be abundant or limited oxygen in the lake and at what depths the oxygen will be abundant or absent from.

Based on the sampling results, the lake should be classified as mixed or stratified. The lake should also be classified as oligotrophic, mesotrophic and eutrophic. Information should be included in the report that states why these conclusions were made.

Group Five: pH and Alkalinity

Group Five will be responsible for determining the pH at the surface of the lake. This information should be used to classify the lake as acidic, neutral or basic.

Group Five will also be testing the alkalinity of the lake. Alkalinity is the capacity to neutralize acid. A well-buffered lake will neutralize more acid and thus be able to withstand the effects of acid rain better than a less buffered lake.

Group Five should make a hypothesis before testing the water as to whether they think the lake is acidic, basic or neutral. A second hypothesis should be made concerning whether the lake is a good or poor buffer for acid rain.

Alkalinity will be tested with Hach kits and measured in ppm of calcium carbonate. An alkalinity value below 50 ppm is considered low; a value of 200 ppm is quite high. A high value means the lake is a good buffer and resistant to acid rain.

Group Six: Algae and Zooplankton

Group Six is responsible for collecting and identifying algae and zooplankton samples. Whenever samples are collected, the sample location should be recorded. The samples should be collected using a plankton net which concentrates organisms by straining them out of the water. The plankton net is made of very fine material so that very small organisms can be collected. When lowering the plankton net be sure the cup goes down first. Lower the net until it is about 1 meter from the bottom then pull the net up slowly and wash the organism down into the cup.

The collected plankton should be carried back to the lab and investigated under a microscope. Next, use reference materials to attempt to identify the zooplankton and algae in the sample. Final reports should include drawings, descriptions of organisms (such as locomotion) and numbers of each type of organism found.

Use of Sampling Equipment

(LESSON FOUR IN THE "WHAT IS A LAKE?" UNIT)

In preparation for the upcoming sampling trip an orientation with the equipment is necessary. Each piece of equipment in the Lake Superior Ecosystem Learning Kit is labeled and includes instructions for its use.

TOPIC
Day four should be devoted to learning how to use all of the sampling equipment before going to the lake.

LENGTH
45-60 minutes

GOAL
To prepare for efficient and useful sampling.

OBJECTIVE
- *Students will understand how their sampling equipment is used to gain understanding about their topic.*

MATERIALS
- *sampling equipment listed in unit overview*

PROCEDURE

Students should find the equipment they will be using at the lake, learn how to use the equipment, make sure all the equipment is in working order and prepare the equipment for the lake study. Each group should also prepare a data sheet to use for recording data at the lake.

Lake Sampling

(LESSON FIVE OF THE "WHAT IS A LAKE?" UNIT)

Each group should be prepared in this exercise to carry out their duties with minimal assistance.

TOPIC
Lake sampling day.

LENGTH
2-8 hours

GOAL
To practice safe and effective research sampling technique.

OBJECTIVE
- *Students will use teamwork and sampling equipment to obtain the data for their topic.*

MATERIALS
- *sampling equipment listed in unit overview*

PROCEDURE

1. Picking a site

Group One will select the sampling site and mark the location on a map. The depth should be measured and recorded by group one. A depth of over 10 meters is preferable for this study. Group One should also record general weather data.

2. Water samples

Groups Two, Four and Five will work together to lower the Van Doran sampler. The groups should use the sampler to collect water samples at each meter of depth. When the sampler arrives on the surface the temperature should be taken first, and then the dissolved oxygen group and pH and alkalinity group, can split the remaining water for analysis.

3. Water clarity

Group Three will take their Secchi disk readings from the shady side of the boat or pier.

4. Plankton

Group Six will use their plankton net to sample for algae and zooplankton in the water column.

5. Wrap-up

Care must be taken not to release any contaminated water back into the lake. Contaminated water should be transported back to the lab and deposited in the appropriate place.

Analyzing the Data, Writing the Report, Presenting Results

(LESSON SIX OF THE "WHAT IS A LAKE?" UNIT)

Collecting the data is only the first step in a research project. Next, the results need to be assessed and made available to others. Students will decide what their results mean, and then present their results orally and in a written format.

TOPIC
Final procedures when research sampling has been completed.

LENGTH
1-2 class periods

GOAL
To understand that after data is collected, the results need to be organized and presented.

OBJECTIVES
- *Students will work with their groups to interpret their data.*
- *Students will present their views in written and oral form.*

MATERIALS
- *handout of scientific research paper outline*

BACKGROUND

An outline of a scientific research paper is included for student use.

Outline of a scientific research paper

The research paper must contain the following ingredients:

1. Title page including: title, class, group members and the date.
2. Introduction: one or two paragraphs explaining what your group is researching and what your hypothesis is before the experiment.
3. Materials and Methods: one to three paragraphs explaining how you conducted the test that you are performing. Be specific.
4. Data: include tables and graphs which highlight your data
5. Results: explain the data in written terms.
6. Discussion: state and explain any findings that your group has concluded. Accept or reject your original hypothesis.
7. Literature Cited: include any reference materials.

GETTING READY

Prepare handouts of scientific paper outline.

PROCEDURE

1. Introduction

This day is devoted to analyzing the results of the data collected at the lake. Students should record their data in a chart, table and/or graph. Each group should draw a conclusion about the trophic status of the lake they are studying.

2. Presentations

Students should then present the results of their research to the rest of the the class. Time should be given for questions. A nice closing might be to have the class form a large circle and discuss the overall results of the lake study and determine the trophic status of the lake using all of the results from all of the groups.

EXTENSIONS

- List any concerns that the groups may have noticed about the health of the lake. Create an environmental service project to address their concerns.
- Sample the lake at different times of the year and look for seasonal changes.
- Sample the lake for heavy metals or other contaminants.
- Research a topic on the Internet or in the library.
- Bring in a research person to talk to the class.
- Create dilemmas on index cards involving lake issues. Then have students read, discuss, make judgements and write about the dilemmas.

Oxygen data for the western arm of Lake Superior, 1990-1991

Oxygen Profile (mg/L) Depth (m)	0	5	10	15	20	25	30	35	40	45
1990										
Apr 29	14.2	14.1	14.1	*	*	*	*	*	*	*
May 12	14.3	14.6	14.7	14.7	14.9	14.9	15.0	15.0	14.2	*
May 26	14.4	14.1	14.0	14.0	14.0	14.0	14.0	14.0	*	*
Jun 23	6.2	6.4	6.8	7.1	7.6	7.9	7.9	8.0	7.9	7.9
Jun 29	11.9	12.2	12.3	12.5	13.3	13.9	14.0	14.1	14.2	14.3
Jul 6	10.5	10.6	11.4	12.8	13.2	13.3	13.4	13.3	13.2	13.2
Jul 20	9.8	9.8	10.8	12.6	13.9	14.0	14.0	14.0	*	*
Aug 3	9.9	10.5	12.1	13.2	13.3	13.3	13.3	13.3	13.4	13.5
Aug 17	9.1	10.4	13.1	13.3	13.3	13.4	13.3	13.3	13.3	13.3
Aug 22	9.8	9.5	10.2	10.4	10.9	10.9	10.9	11.0	11.0	11.0
Sept 6	9.5	10.0	10.3	10.5	10.8	11.0	11.4	12.9	13.3	*
Sept 9	9.3	9.4	9.4	9.8	10.6	11.0	11.3	12.0	12.7	12.8
Sept 10	9.2	9.1	9.7	9.8	10.5	10.6	10.9	11.3	11.8	12.4
Sept 23	8.9	8.8	8.9	8.8	8.7	8.7	8.7	8.7	*	*
Oct 12	10.2	10.4	10.6	10.6	10.8	12.2	12.7	12.8	12.7	*
Oct 24	11.3	11.3	11.2	11.2	11.2	11.1	11.1	11.1	11.3	11.3
Oct 29	11.2	11.4	11.4	11.4	11.6	11.8	11.8	11.8	12.1	12.3
1991										
May 10	13.0	13.0	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
Jun 15	12.1	12.9	13.4	14.0	14.4	14.6	14.8	14.9	15.1	15.1
Jul 5	10.0	11.5	12.4	13.4	13.6	13.9	14.0	14.0	14.0	14.1
Aug 13	8.9	10.2	10.9	12.5	13.7	15.2	15.6	16.2	16.2	15.9

* Data not available

Temperature data for the western arm of Lake Superior, 1990-1992

Temperature Profile (C) Depth (m)	0	5	10	15	20	25	30	35	40	45	50
1990											
Apr 29	2.2	2.2	2.2	0.0	*	*	*	*	*	*	*
May 12	3.4	3.1	3.1	3.1	3.1	3.1	3.0	3.1	3.1	*	*
May 26	3.7	3.4	3.4	3.4	3.4	3.4	3.4	3.4	*	*	*
Jun 23	11.	9.9	8.8	7.0	5.3	4.8	4.6	4.5	4.5	4.4	4.4
Jun 29	12.9	10.8	10.3	10.0	7.6	6.7	6.4	6.1	6.0	5.8	5.8
Jul 6	14.8	13.8	9.7	6.8	5.8	5.4	5.1	4.9	4.7	4.5	4.4
Jul 20	19.0	18.5	13.6	8.0	6.2	5.8	5.5	5.1	*	*	*
Aug 3	18.6	16.2	10.3	6.8	6.2	5.6	5.5	5.2	5.0	4.7	4.6
Aug 17	19.4	13.1	6.6	5.7	5.4	4.9	4.7	4.6	4.5	4.2	4.2
Aug 22	16.8	16.6	14.9	14.4	13.3	13.3	13.2	13.1	13.1	13.0	13.0
Sept 6	18.5	16.2	15.3	13.8	13.0	12.6	10.8	6.9	5.2	*	*
Sept 9	19.4	17.2	16.5	15.9	13.3	11.8	10.2	8.5	5.8	4.9	*
Sept 10	18.0	17.5	16.6	15.8	12.5	12.0	10.6	9.7	8.1	4.9	*
Sept 23	4.0	14.2	14.2	14.2	14.2	14.2	14.2	14.2	*	*	*
Oct 12	12.0	12.0	11.9	11.8	9.0	7.4	5.8	5.2	4.9	*	*
Oct 24	8.5	8.6	8.6	8.5	8.4	8.3	7.9	7.3	7.1	6.8	6.7
Oct 29	9.0	8.4	8.4	8.3	7.9	7.5	7.3	7.0	6.6	6.3	*
1991											
May 10	2.1	2.2	2.0	2.0	1.9	1.9	1.9	2.1	2.2	2.2	2.2
Jun 15	8.6	8.2	7.3	6.6	6.1	5.9	5.5	5.3	4.8	4.7	4.6
Jul 5	15.5	10.0	9.4	7.8	7.6	7.5	7.2	7.0	6.8	6.6	6.1
Aug 13	23.4	17.1	16.5	13.8	8.3	5.7	4.7	4.3	4.1	4.0	3.9
Aug 27	*	18.2	17.4	17.3	17.0	15.7	9.9	5.8	4.8	*	*
Sept 19	15.2	15.2	15.2	15.1	6.8	5.1	4.2	4.0	3.9	3.9	*
Oct 11	*	5.8	5.6	5.6	5.6	5.5	5.4	5.1	4.6	*	*
1992											
Mar 26	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	*	*

* Data not available

Lake Effects

Appendix

Making your own Lake Superior Floor Map

MATERIALS

- large rectangle of light canvas, blue tarp or heavy drop cloth, either 9' by 12' or 10' by 15'
- tacks or large clips
- overhead transparency of Lake Superior (copy from map in this book)
- extra drop cloth
- pencils
- heavy markers
- (optional) fabric paints

How do you bring Lake Superior into your classroom? Well, short of plugging up the floor drains and letting the taps go, this may be the best way. Many of the activities in this guide suggest or require the use of a large floor map of Lake Superior. Here's how you (or your students!) can make one.

METHOD

1. Set up

Find a blank wall that has some way of pinning up your tarp, e.g. tacking into the wall or clipping into the ceiling or moulding. Hang the tarp on this wall, oriented horizontally; you'll probably need chairs or stools to do this.

Set up the overhead projector at the right distance so that the Lake Superior image covers most of the tarp.

2. Draw the outline

With a pencil, lightly draw the outline of Lake Superior. Pick out whatever details you think you'll want, like cities, watershed boundaries, state or country boundaries, etc. It helps to turn off the projector when you think you're done, to see if you missed anything.

3. Fill it out

Take the tarp down from the wall and, if cloth, place it on top of the extra drop cloth. Using the heavy marker, retrace the pencil outline. Fill in other details as appropriate. To get the water part of the lake blue, try fabric paint or regular acrylic paint.

4. Use it!

This map can be at the center (literally!) of your Lake Superior curriculum. Try it in "All the Water in the World," "The Incredible Journey," "Depth Soundings," "Getting to Know the Watershed," "Lake Superior Poem," "Lake Superior Geography Concentration"... or your own creation!

Glossary

AOC
"Area of Concern." Under the Great Lakes Water Quality Agreement, one of 42 pollution "hotspots" throughout the Great Lakes. Eight are on Lake Superior.

abiotic
The "non-living" part of an ecosystem, including water, minerals, etc. See "biotic."

atmospheric deposition
Toxics and other materials that are added to the lake through precipitation.

ballast
Extra weight, typically in the form of water, added to a ship's hold to make it sturdier when empty. Common source of exotic species dispersal.

basalt
Dark volcanic rock that formed with the Precambrian rifting in the Lake Superior region.

basin
See "watershed."

bioaccumulation
The net accumulation of a substance by an organism as a result of uptake from all environmental sources.

biodiversity
A measure of the biological and genetic complexity of a given population, habitat or region.

biomagnification
A biological process in which toxins magnify in the food chain, so that top predators have much higher levels of toxics than the water itself.

biotic
The "living" part of an ecosystem, including plants and animals. See "abiotic."

DNR
"Department of Natural Resources." State agencies in Minnesota, Wisconsin and Michigan with much of the responsibility for natural resources and Lake Superior.

ecosystem
The combined biotic and abiotic factors of a habitat or region, expressed as a set of interrelationships.

endangered
The strongest federal designation, under the Endangered Species Act, for a plant or animal that is threatened with extinction. See also "threatened."

epilimnion
The upper part of a lake that is warmed by the sunshine; in summer, this is warmer than the water below and thus floats on top. See "hypolimnion" and "thermocline."

estuary
Protected mixing zone between a river and an ocean or lake. Typically a wetland environment. Very important for nesting of birds and fish.

eutrophic
Designation for an aquatic ecosystem that is high in nutrients. See "oligotrophic."

exotic
Designation for a species that is not naturally found in a given ecosystem but which was transferred there by human action. See "native."

extrusive
An igneous rock, like basalt, that formed on the surface of the earth from quick-cooling magma.

fetch
The distance over which a prevailing wind has blown. A greater fetch leads to larger waves.

food web
One way of expressing the interrelationships found in an ecosystem.

granite
Igneous rock which comprises most of the Canadian shield and underlies the northeastern corner of Lake Superior.

groundwater
Water found in aquifers or other natural underground storage.

habitat
The set of food, water and shelter required by any specific organism to survive.

heat sink
Any large mass such as water that absorbs heat and then releases it into the environment. Serves as a thermal 'flywheel.'

hypolimnion
The deepest part of the water column composed of cold water year-round. See "epilimnion" and "thermocline."

IJC
"International Joint Commission." Agency formed by the Canadian and U.S. governments to deal with boundary waters concerns. Oversees Great Lakes Water Quality Agreement.

igneous
Term for rocks such as basalt and granite that formed by cooling of magma.

indicator species
A plant or animal that is used by scientists and policy makers to indicate the health of the ecosystem in which it is found.

intrusive
An igneous rock, like granite or gabbro, that was formed below the surface of the earth, identified by its large crystals. See "extrusive."

LSC
"Lake Superior Center." Private, non-profit education organization located in Duluth.

lake effect
General term for weather phenomena directly associated with the open lake, especially the increased snowfall on the downwind shore of the lake.

limestone
Sedimentary rock formed underneath oceans and seas, found around Pictured Rocks National Lakeshore.

longshore current
Water current formed by predominant wind directions. It flows around Lake Superior in general in a counter-clockwise direction.

MNR
"Ministry of Natural Resources." Ontario provincial agency responsible for natural resources.

microclimate
Very regional weather conditions due to proximity to the lake.

native
A plant or animal species that arrived or evolved in the ecosystem without intervention from humans. See "exotic."

nonpoint source
Pollution that cannot be traced to a single source but comes from general human action.

nuisance
Exotic species that cause problems for humans, such as the zebra mussel.

oligotrophic
Designation for an aquatic ecosystem, such as Lake Superior, that is very low in nutrients. See "eutrophic."

overturn
The action of a lake when the water column is a consistent temperature and the water can mix up and down. In Lake Superior this period is much longer than in inland lakes.

phytoplankton
Small and microscopic plants, which generally make up the base of the aquatic food chain. See "zooplankton."

plankton
See "phytoplankton" and "zooplankton."

point source
Pollution that can be traced to a single source such as a pipe, smokestack or exhaust.

RAP
"Remedial Action Plan." Planning and action process for the restoration of the 42 AOCs.

removal time
The time it takes for 90% of a lake's water to be replaced, generally three times as long as the retention time.

retention time
The time it takes for an volume of water equal to a lake's volume to enter or leave the lake.

runoff
Precipitation that has fallen on the ground but is not absorbed by the soil.

sandstone
Sedimentary rock associated with shallow seas and seas advancing over sand dunes. Common along the south shore of Lake Superior, especially Pictured Rocks and Apostle Islands.

sedimentary
Rock formed by deposits of particles on the bottom of a lake, sea or ocean. Typically layered. The common sedimentary rocks of Lake Superior are sandstones and limestones.

seiche
The oscillation of the lake level following a storm surge, resulting in lake water sloshing back and forth over a great distance.

spawning
The reproductive time of fish, involving the laying of eggs by the females and sperm by the males. Typically involves a change in habitat, such as going upstream or to shallow shoals.

stocking
Addition by people of young fish into the lake or tributaries, typically to support the sport fisheries.

storm surge
The rise in water level associated with a dominant wind direction or low pressure area.

taconite
A form of low-grade iron ore found in northeastern Minnesota and commonly shipped across Lake Superior.

threatened
The second strongest federal designation, under the Endangered Species Act, for a plant or animal that is potentially in danger of extinction. See also "endangered."

toxins
Substances that are hazardous to life, both human and other animals. Common toxins in Lake Superior are PCBs, dioxins and mercury.

trophic level
The level of a species in the food chain, for example producer, primary consumer, secondary consumer, decomposer, etc.

volcanic
Same as "extrusive."

watershed
The geographic area from which streams and rivers flow into a given river or lake.

zooplankton
Small and microscopic animals, which generally make up the primary consumers of the aquatic food chain. See "phytoplankton."

Resources

ADDITIONAL LAKE SUPERIOR EDUCATION RESOURCES

NON-PROFIT ORGANIZATIONS

Lake Superior Center
353 Harbor Drive, Duluth, MN 55802
(218) 720-3033
Featuring Superior Lakewatch; School Programs; Learning Kits—*Lake Superior A to Z, Lake Superior People and Places, The Great Lake Superior, Lake Superior Ecosystem*

The Center for the Great Lakes
435 North Michigan Avenue - Suite 1408
Chicago, IL 60611 • (312) 645-0901
or
The Centre for the Great Lakes Foundation
320-1/2 Bloor Street, West, Suite 301
Toronto, ON M5S 1W5
(416) 921-7662

SEA GRANT PROGRAMS

Minnesota Sea Grant Extension Program
208 Washburn Hall, UMD;
2305 E. 5th Street
Duluth, MN 55812
(218) 726-8106
Exotic Species Traveling Trunk

University of Wisconsin
Sea Grant Institute
143 Sundquist Hall, UWS
Superior, WI 54880 • (715) 394-8472

Michigan Sea Grant College Program
Michigan State University
334 Natural Resources Building
East Lansing, MI 48824-1222
(517) 353-9568
or
The University of Michigan
2200 Bonisteel Boulevard
Ann Arbor, MI 48109
(313) 764-1138
(for publications)

GOVERNMENT AGENCIES

International Joint Commission
Great Lakes Regional Office
100 Ouellette Avenue, Eighth Floor
Windsor, ON N9A 6T3 • (519) 256-7821
or
P.O. Box 32869, Detroit, MI 48232-2869
(313) 226-2170

Canada Ontario Agreement
Environment Canada
Communications Directorate
25 St. Clair Avenue East, Room 600
Toronto, ON M4T 1M2 • (416) 973-6467
or
Ontario Ministry of the Environment
Public Information Centre
135 St. Clair Avenue West
Toronto, ON M4V 1P5 • (416) 323-4321

Great Lakes Commission
The Argus Building, 400 Fourth Street
Ann Arbor, MI 48103-4816
(313) 665-9135

Ashland Fishery Resources Office
U.S. Fish and Wildlife Service
2800 Lakeshore Drive East
Ashland, WI 54806 • (715) 682-6185

Lake Superior Unit
Ontario Ministry of Natural Resources
P.O. Box 5000, 435 James Street South
Thunder Bay, ON P7C 5G6
(807) 475-1375

Fisheries Division, Michigan Department of Natural Resources
P.O. Box 30028, Lansing, MI 48909
(517) 373-1280

NATIVE PEOPLE ORGANIZATIONS

The Great Lakes Indian Fish and Wildlife Commission
P.O. Box 9, Odanah, WI 54861
(715) 682-6619

Chippewa-Ottawa Treaty Fishery Management Authority
Albert (Big Abe) Le Blanc Building
186 E. Three Mile Road
Sault Ste. Marie, MI 49783
(906) 632-0043

Union of Ontario Indians
813 Danforth Avenue
Toronto, ON M4C 1J2 • (416) 693-1305

OTHER

Institute of Water Research
Michigan State University
334 Natural Resources Building
East Lansing, MI 48824-1222
(517) 353-3742

PLACES TO VISIT FOR LAKE SUPERIOR PROGRAMS

Lake Superior Center, Duluth
(218)720-3033

Hartley Nature Center
31 W. College St., Duluth, MN 55812
(218)724-6735

University of Minnesota, Duluth Outdoor Program • (218)726-6533

U.S. Coast Guard, Duluth • (218)720-5286

Minnesota DNR Fisheries
5351 North Shore Dr.
Duluth, MN 55804 • (218)723-4785

Minnesota Sea Grant
208 Washburn Hall, UMD
2305 E. 5th St., Duluth, MN 55812
(218)726-8106

Canal Park Marine Museum/Army Corps of Engineers, Canal Park
Duluth, MN 55802 • (218)727-2497

Split Rock Lighthouse/
MN Historical Society
2010 Hwy. 61E , Two Harbors, MN 55616
(218)226-4372

THE DEPOT:
506 West Michigan St.
Duluth, MN 55802
- The Duluth Children's Museum (218)722-8563
- The Duluth Art Institute (218)727-8013
- The St. Louis County Historical Society (218)727-8011
- The Lake Superior Museum of Transportation (218)727-0687

Lake County Historical Society
Depot Building , Two Harbors, MN 55616
(218)834-4898

William A. Irvin
350 Harbor Dr., Duluth, MN 55802
(218)722-5573

Old Firehouse and Police Museum/
SS Meteor Maritime Museum
402 23rd Ave. E., Superior, WI 54880
Chamber of Commerce (715)394-7716

Fairlawn/Douglas County Historical Society
906 Harbor View Pkwy E.
Superior, WI 54880 • (715)394-5712

Glensheen
3300 London Rd., Duluth, MN 55804
(218)724-8863/8864

Grand Portage National Monument
Grand Portage, MN • (218)475-2202

Old Fort William
Vickers Heights
Thunder Bay, ON POT 2ZO
(807)473-2308

Lake Superior

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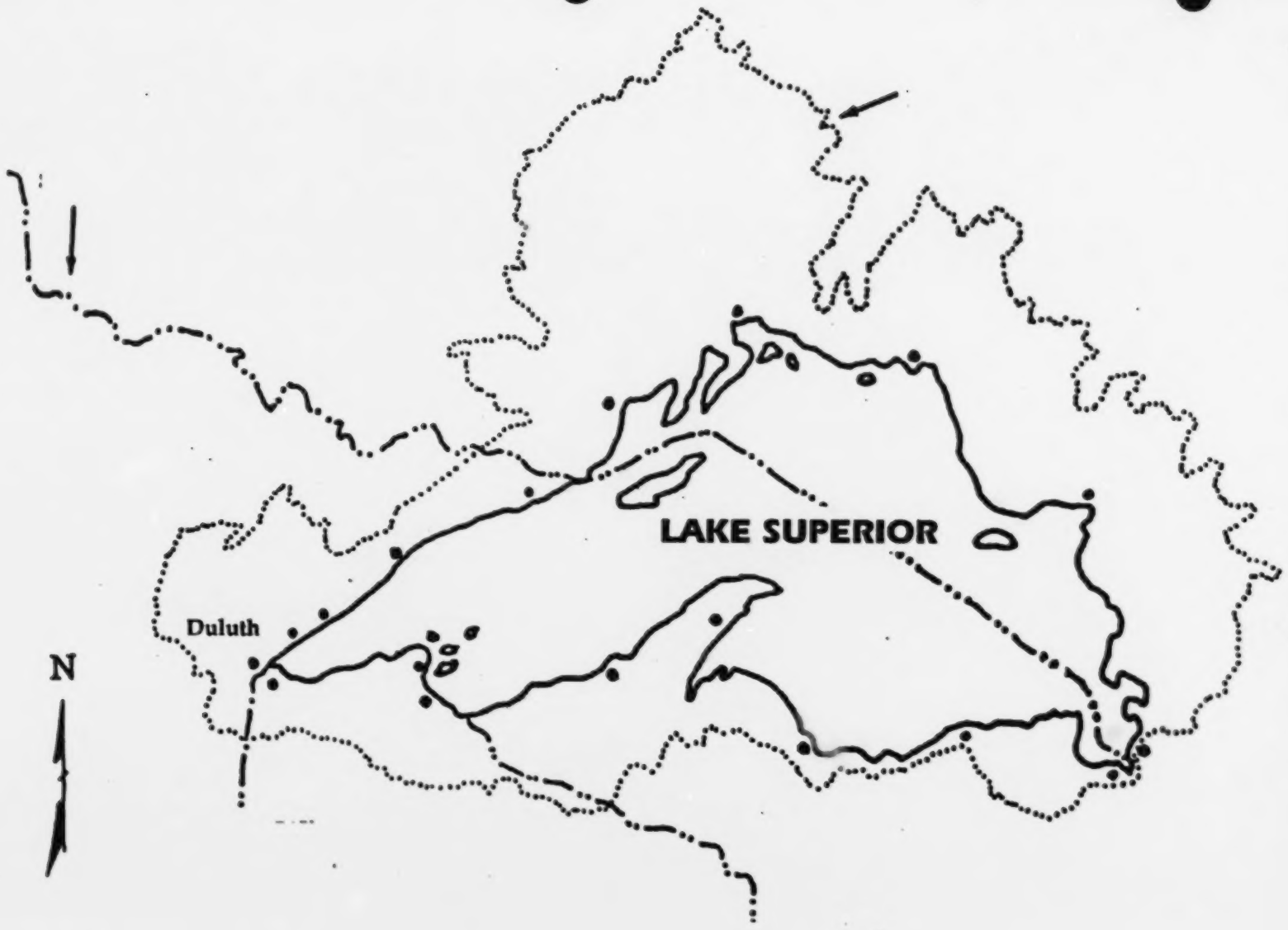
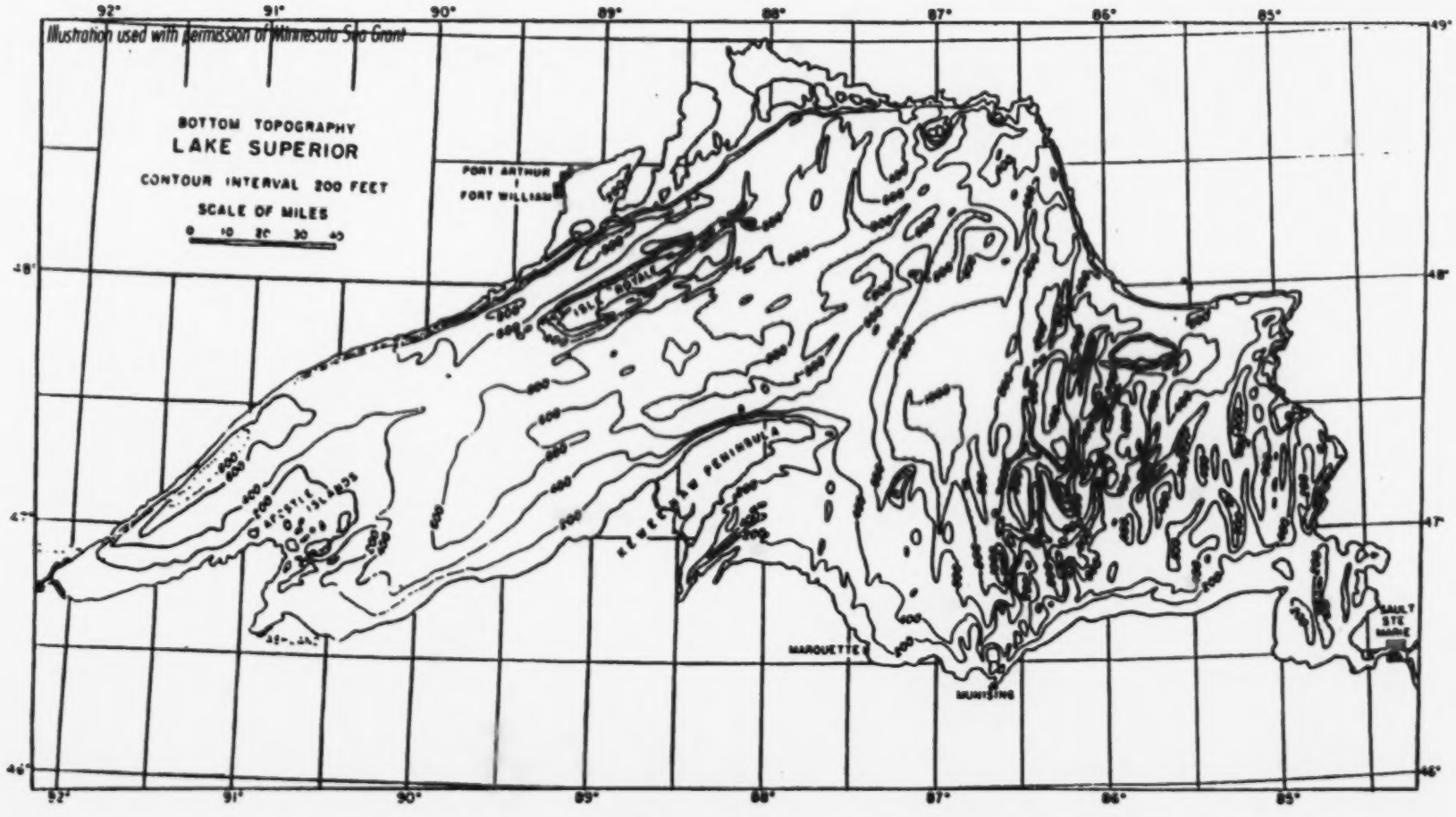


Lake Superior and Drainage Basin



Bottom Topography of Lake Superior

Great Lakes Data Chart

PHYSICAL FEATURES AND POPULATION							
		Superior	**Michigan**	**Huron**	**Erie**	**Ontario**	**Totals**
Elevation	(feet)	600	577	577	569	243	
	(metres)	183	176	176	173	74	
Length	(miles)	350	307	206	241	193	
	(km)	563	494	332	388	311	
Breadth	(miles)	160	118	183	57	53	
	(km)	257	190	245	92	85	
Average Depth	(feet)	483	279	195	62	283	
	(metres)	147	85	59	19	86	
Maximum Depth	(feet)	1,332	925	750	210	800	
	(metres)	406	282	229	64	244	
Volume	(cu. miles)	2,900	1,180	850	116	393	5,439
	(cu. km)	12,100	4,920	3,540	484	1640	22,684
AREA							
Water	(sq. mi.)	31,700	22,300	23,000	9,910	7,340	94,250
	(sq. km.)	82,100	57,800	59,600	25,700	18,960	244,160
Land Drainage Area	(sq. mi.)	49,300	45.600	51,700	30,140	24,720	201,460
	(sq. km.)	127,700	118,00	134,100	78,000	64,030	521, 830
Total	(sq. mi.)	81,000	67,900	74,700	40,050	32,060	295,710
	(sq. km.)	209,800	175,800	193,700	103,700	82,990	765,990
Shoreline Length	(miles)	2,726	1,638	3,827	871	712	10,210
	(km)	4,385	2,633	6,157	1,402	1,146	17,017
Retention Time	(years)	191	99	22	2.6	6	
Population: U.S.	(1990)	425,548	10,057,026	1,502,687	10,017,530	2,704,284	24,707,075
Population: Canada	(1991)	181,573		1,191,467	1,664,639	5,446,611	8,484,290
Totals		607,121	10,057,026	2,694,154	11,682,169	8,150,895	33,191,365
Outlet		St. Marys River	Straits of Mackinac	St. Clair River	Niagara River Welland Canal	St. Lawrence River	

State of the Great Lakes Report—1995

Lake Superior Fish Consumption Advisory

New meal advise for eating sport fish from Lake Superior is the result of recent collaboration between Minnesota and the other Great Lake states. Lake Superior fish contaminant data from Minnesota, Wisconsin and Michigan were combined for this new advice. In addition, the new meal advice is also based on recent studies of cooking methods for Lake Superior fish. These studies show that after properly cleaning, trimming and cooking fish, PCB levels in fish meal are reduced by as much as 50 percent. The new format is another result of this interstate collaboration and is being considered for future advisory booklets.

In order to follow this advisory, you should follow the directions for correctly trimming, skinning and cooking these fish. The meal advisory that follows is for eating trimmed, skinned and cooked fish.

On meal is assumed to be one-half pound of fish (weight before cooking) for a 150-pound person. This meal advice is equally protective for larger people who eat larger meals and smaller people who eat smaller meals.

Fish Species	No Restriction	One Meal a Week	One Meal A Month	One Meal Every Two Months	Do Not Eat
LAKE TROUT		less than 20"	20-27"	more than 27"	
SISCOWET				less than 20"	more than 20"
CHINOOK SALMON			All sizes		
COHO SALMON		All sizes			
WHITEFISH		All sizes			
LAKE HERRING		All sizes			
RAINBOW TROUT		All sizes			
BROWN TROUT			All sizes		
SMELT[1]	All sizes				

[1]No restrictions on untrimmed smelt cooked with the skin on.

This advice is based primarily on the PCBs found in the fish. Due to the mercury that is also found in Lake Superior fish, it is especially important that women of child-bearing age space meals out according to the advisory. If you are eating a fish from the "One Meal a Month" category, wait one month before eating your next meal of sport fish.

Comments, Please!

We value your ideas and comments about this Lake Superior curriculum. And we'd like to send you our quarterly Lake Superior education newsletter *LakeEffects*. After you've used (or tried to use!) this curriculum guide, please send us this form with your thoughts.

What grade(s) and subject(s) do you teach?

Where did you get your copy of *LakeEffects: The Lake Superior Activity Guide?*

What lessons have you used?

How did these lessons work for you?

What changes would you like to see in future editions of this curriculum guide?

Any general comments?

❑ Yes! Please send me the quarterly newsletter *LakeEffects.*

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Mail to Lake Superior Center, 353 Harbor Drive, Duluth MN 55802 or Fax to (218) 720-3407